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DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

RIN 0648- XB105

Takes of Marine Mammals Incidental to Specified Activities; Three Marine Geophysical Surveys in the Northeast Pacific Ocean, June through July, 2012

AGENCY: National Marine Fisheries Service, National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Notice; proposed incidental harassment authorization; request for comments.

SUMMARY: We have received an application from the Lamont-Doherty Earth Observatory, a part of Columbia University, for an Incidental Harassment Authorization to take marine mammals, by harassment, incidental to conducting three consecutive marine geophysical surveys in the northeast Pacific Ocean, June through July, 2012.

DATES: Comments and information must be received no later than [insert date 30 days after date of filing for public inspection with the OFFICE OF THE FEDERAL REGISTER].

ADDRESSES: Comments on the application should be addressed to Tammy C. Adams, Acting Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service, 1315 East-West Highway, Silver Spring, MD 20910-3225. The mailbox address for providing email comments is ITP.Cody@noaa.gov. We are not responsible for e-mail comments sent to addresses other than the one provided here. Comments sent via email, including all attachments, must not exceed a 10-

megabyte file size.

All submitted comments are a part of the public record and we will post to <http://www.nmfs.noaa.gov/pr/permits/incidental.htm#applications> without change. All Personal Identifying Information (for example, name, address, etc.) voluntarily submitted by the commenter may be publicly accessible. Do not submit confidential business information or otherwise sensitive or protected information.

To obtain an electronic copy of the application containing a list of the references used in this document, write to the previously mentioned address, telephone the contact listed here (see FOR FURTHER INFORMATION CONTACT), or visit the internet at:

<http://www.nmfs.noaa.gov/pr/permits/incidental.htm#applications>.

The National Science Foundation's (Foundation) draft Environmental Assessment (Assessment) pursuant to the National Environmental Policy Act of 1969 and Executive Order 12114 is also available at the same internet address. The Assessment incorporates an "Environmental Assessment of a marine geophysical survey by the R/V Marcus G. Langseth in the northeastern Pacific Ocean, June - July 2012," prepared by LGL Limited environmental research associates, on behalf of the Foundation. The public can view documents cited in this notice by appointment, during regular business hours, at the aforementioned address.

FOR FURTHER INFORMATION CONTACT: Jeannine Cody or Howard Goldstein, National Marine Fisheries Service, Office of Protected Resources, (301) 427-8401.

SUPPLEMENTARY INFORMATION:

Background

Section 101(a)(5)(D) of the Marine Mammal Protection Act of 1972, as amended

(MMPA; 16 U.S.C. 1361 et seq.) directs the Secretary of Commerce to authorize, upon request, the incidental, but not intentional, taking of small numbers of marine mammals of a species or population stock, by United States citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region if: (1) we make certain findings; (2) the taking is limited to harassment; and (3) we provide a notice of a proposed authorization to the public for review.

We shall grant authorization for the incidental taking of small numbers of marine mammals if we find that the taking will have a negligible impact on the species or stock(s), and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant). The authorization must set forth the permissible methods of taking; other means of effecting the least practicable adverse impact on the species or stock and its habitat; and requirements pertaining to the mitigation, monitoring and reporting of such takings. We have defined "negligible impact" in 50 CFR 216.103 as "...an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival."

Section 101(a)(5)(D) of the Marine Mammal Protection Act established an expedited process by which citizens of the United States can apply for an authorization to incidentally take small numbers of marine mammals by harassment. Section 101(a)(5)(D) of the Act establishes a 45-day time limit for our review of an application followed by a 30-day public notice and comment period on any proposed authorizations for the incidental harassment of small numbers of marine mammals. Within 45 days of the close of the public comment period, we must either issue or deny the authorization

and must publish a notice in the Federal Register within 30 days of our determination to issue or deny the authorization.

Except with respect to certain activities not pertinent here, the Marine Mammal Protection Act defines "harassment" as: any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A harassment]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [Level B harassment].

Summary of Request

We received an application on January 27, 2012, from the Lamont-Doherty Earth Observatory (Observatory) for the taking by harassment, of small numbers of marine mammals, incidental to conducting three separate marine geophysical surveys in the northeast Pacific Ocean. We determined the application complete and adequate on March 27, 2012.

The Observatory, with research funding from the U.S. National Science Foundation (Foundation), plans to conduct three research studies on the Juan de Fuca Plate, the Cascadia thrust zone, and the Cascadia subduction margin in waters off the Oregon and Washington coasts. The Observatory has proposed to conduct the first survey from June 11 through July 5, 2012, the second survey from July 5 through July 8, 2012, and the third survey from July 12 through July 23, 2012.

The Observatory plans to use one source vessel, the R/V Marcus G. Langseth (Langseth), a seismic airgun array, a single hydrophone streamer, and ocean bottom

seismometers to conduct the geophysical surveys.

The proposed surveys will provide data necessary to:

- Characterize the evolution and state of hydration of the Juan de Fuca plate at the Cascadia subduction zone;
- Provide information on the buried structures in the region; and
- Assess the location, physical state, fluid budget, and methane systems of the Juan de Fuca plate boundary and overlying crust.

The results of the three studies would provide background information for generating improved earthquake hazards analyses and a better understanding of the processes that control megathrust earthquakes which are produced by a sudden slip along the boundary between a subducting and an overriding plate.

In addition to the operations of the seismic airgun array and hydrophone streamer, and the ocean bottom seismometers (seismometers), the Observatory intends to operate a multibeam echosounder and a sub-bottom profiler continuously throughout the surveys.

Acoustic stimuli (i.e., increased underwater sound) generated during the operation of the seismic airgun arrays, may have the potential to cause a short-term behavioral disturbance for marine mammals in the survey area. This is the principal means of marine mammal taking associated with these activities and the Observatory has requested an authorization to take 26 species of marine mammals by Level B harassment. We do not expect that the use of the multibeam echosounder, the sub-bottom profiler, or the ocean bottom seismometer will result in the take of marine mammals and will discuss our reasoning later in this notice. Also, we do not expect take to result from a collision with the Langseth because it is a single vessel moving at relatively slow speeds (4.6 knots

(kts); 8.5 kilometers per hour (km/h); 5.3 miles per hour (mph)) during seismic acquisition within the survey, for a relatively short period of time. It is likely that any marine mammal would be able to avoid the vessel.

Description of the Specified Activities

Juan de Fuca Plate Survey

The first proposed seismic survey would begin on June 11, 2012, and end on July 5, 2012. The Langseth would depart from Astoria, Oregon on June 11, 2012, and transit to the survey area in the northeast Pacific Ocean in international waters and the Exclusive Economic Zones of the United States and Canada. The study area will encompass an area bounded by approximately 43-48 degrees (°) North by approximately 124-130° East (see Figure 1 in the Observatory's Application #1). Water depths in the survey area range from approximately 50 to 3,000 meters (m) (164 feet (ft) to 1.9 miles (mi)). At the conclusion of the first survey, the Langseth would begin a second three-day seismic survey on July 5, 2012, in the same area.

Typically, two-dimensional surveys such as this one, acquire data along single track lines with wide intervals; cover large areas; provide a coarse sampled subsurface image; and project less acoustic energy into the environment than other types of seismic surveys. During this survey, the Langseth would deploy a 36-airgun array as an energy source, an 8-kilometer (km)-long (4.9 mi-long) hydrophone streamer, and 46 seismometers. The seismometers are portable, self-contained passive receiver systems designed to sit on the seafloor and record seismic signals generated primarily by airguns and earthquakes. As the Langseth tows the airgun array along the survey lines, the hydrophone streamer receives the returning acoustic signals and transfers the data to the vessel's on-board

processing system. The seismometers also record and store the returning signals for later analysis.

The Observatory plans to discharge the airgun array along three long transect lines and three semi-circular arcs using the seismometers as the receivers and then repeat along the long transect lines in multichannel seismic mode using the 8-km streamer as the receiver (see Figure 1 in the Observatory's Application #1). Also, the Observatory will use one support vessel, the R/V Oceanus (Oceanus) to deploy 46 seismometers on the northern onshore-offshore line, retrieve the 46 seismometers from the northern line, and then deploy 39 seismometers on the southern onshore-offshore lines and retrieve them at the conclusion of the survey.

The first study (e.g., equipment testing, startup, line changes, repeat coverage of any areas, and equipment recovery) will require approximately 17 days to complete approximately 3,051 km (1,895.8 mi) of transect lines. The total survey effort including contingency will consist of approximately 2,878 km (1,788.3) of transect lines in depths greater than 1,000 m (621.3 mi), 102 km (63.4 mi) in depths 100 to 1,000 m (328 to 3,280 ft), and 71 km (44.1 mi) in water depths less than 100 m (328 ft). The northern and southern onshore-offshore lines are 70 to 310 km (43.4 to 192.6 mi) and 15 to 450 km (9.3 to 279.6 mi) from shore, respectively.

Data acquisition will include approximately 408 hours of airgun operations (i.e., 17 days over 24 hours). The Observatory, the Langseth's operator, will conduct all planned seismic activities, with on-board assistance by the scientists who have proposed the study. The Principal Investigators for the survey are Drs. S. Carbotte and H. Carton (Lamont Doherty Earth Observatory, New York) and P. Canales (Woods Hole

Oceanographic Institution, Massachusetts). The vessel is self-contained and the crew will live aboard the vessel for the entire cruise.

Cascadia Thrust Zone Survey

The second proposed survey would begin on July 5, 2012, and end on July 8, 2012. The survey would take place in the U.S. Exclusive Economic Zone in waters off of the Oregon and Washington coasts. The study area will encompass an area bounded by approximately 43.5-47° North by approximately 124-125° East (see Figure 1 in the Observatory's Application #2). Water depths in the survey area range from approximately 50 to 1,000 m (164 ft to 0.62 mi). At the conclusion of this survey, the Langseth would return to Astoria, Oregon on July 8, 2012.

The Langseth would deploy a 36-airgun array as an energy source, 12 seismometers, and 48 seismometers (33 in Oregon and 15 in Washington) onshore (on land). As stated previously, as the Langseth tows the airgun array along the survey lines, the seismometers record the returning acoustic signals for later analysis. The Observatory proposes to use the Oceanus to deploy and retrieve the seismometers.

The Observatory plans to discharge the airgun array along a grid of lines off Oregon and along an onshore-offshore line off Washington (see Figure 1 in the Observatory's Application #2).

The proposed study (e.g., equipment testing, startup, line changes, repeat coverage of any areas, and equipment recovery) will require approximately 3 days to complete approximately 793 km (492.7 mi) of transect lines. The total survey effort including contingency will consist of approximately 5 km (3.1 mi) of transect lines in depths greater than 1,000 m (621.3 mi), 501 km (311.3 mi) in depths 100 to 1,000 m (328 to

3,280 ft), and 287 km (178.3 mi) in water depths less than 100 m (328 ft). The northern and southern legs of the onshore-offshore lines are 15 to 70 km (9.3 to 43.5 mi) and 15 to 50 km (9.3 to 31.1 mi) from shore, respectively.

Data acquisition will include approximately 72 hours of airgun operations (i.e., 3 days over 24 hours). The Principal Investigators for the second survey are Drs. A.M Trehu (Oregon State University) and G. Abers and H. Carton (Lamont Doherty Earth Observatory, New York). The vessel is self-contained and the crew will live aboard the vessel for the entire cruise.

Cascadia Subduction Margin Survey

The last seismic survey would begin on July 12, 2012, and end on July 23, 2012. The Langseth would depart from Astoria, Oregon on July 12, 2012, and transit to waters off of the Washington coast. The study area encompasses an area bounded by approximately 46.5-47.5 ° North by approximately 124.5-126° East (see Figure 1 in the Observatory's Application #3). Water depths in the survey area range from approximately 95 to 2,650 m (311.7 ft to 1.6 mi). At the conclusion of this survey, the Langseth would return to Astoria, Oregon on July 23, 2012.

The Langseth would deploy a 36-airgun array as an energy source and an 8-km-long (4.9 mi-long) hydrophone streamer. The Observatory plans to discharge the airgun array along nine parallel lines that are spaced eight km apart. If time permits, the Langseth would survey an additional two lines perpendicular to the parallel lines (see Figure 1 in the Observatory's Application #3).

The proposed study (e.g., equipment testing, startup, line changes, repeat coverage of any areas, and equipment recovery) will require approximately 10 days to complete

approximately 1,147 km (712.7 mi) of transect lines. The total survey effort including contingency will consist of approximately 785 km (487.8 mi) of transect lines in depths greater than 1,000 m (621.3 mi), 350 km (217.5 mi) of transect lines in depths 100 to 1,000 m (328 to 3,280 ft), and 12 km (7.5 mi) of transect lines in water depths less than 100 m (328 ft). The survey area is 32 to 150 km (19.9 to 93.2 mi) from shore.

Data acquisition will include approximately 240 hours of airgun operations (i.e., 10 days over 24 hours). The Principal Investigators for the third survey are Drs. W.S. Holbrook (University of Wyoming), A.M. Trehu (Oregon State University), H.P. Johnson (University of Washington), G.M. Kent (University of Nevada), and K. Keranen (University of Oklahoma). The vessel is self-contained and the crew will live aboard the vessel for the entire cruise.

Vessel Specifications

The Langseth, owned by the Foundation, is a seismic research vessel with a quiet propulsion system that avoids interference with the seismic signals emanating from the airgun array. The vessel is 71.5 m (235 ft) long; has a beam of 17.0 m (56 ft); a maximum draft of 5.9 m (19 ft); and a gross tonnage of 3,834 pounds. It's two 3,550 horsepower (hp) Bergen BRG-6 diesel engines drive two propellers. Each propeller has four blades and the shaft typically rotates at 750 revolutions per minute. The vessel also has an 800-hp bowthruster, which is not used during seismic acquisition. The Langseth's operational speed during seismic acquisition will be approximately 4.6 kts (8.5 km/h; 5.3 mph) and the cruising speed of the vessel outside of seismic operations is 18.5 km/h (11.5 mph or 10 kts).

The Langseth will tow the 36-airgun array, as well as the hydrophone streamer during

the first and last surveys, along predetermined lines. When the Langseth is towing the airgun array and the hydrophone streamer, the turning rate of the vessel is limited to five degrees per minute. Thus, the maneuverability of the vessel is limited during operations with the streamer.

The vessel also has an observation tower from which protected species visual observers (observer) will watch for marine mammals before and during the proposed airgun operations. When stationed on the observation platform, the observer's eye level will be approximately 21.5 m (71 ft) above sea level providing the observer an unobstructed view around the entire vessel.

Some minor deviation from these dates is possible, depending on logistics, weather conditions, and the need to repeat some lines if data quality is substandard. Therefore, we propose to issue an authorization to the Observatory that would be effective from June 9, 2012, to August 27, 2012.

Acoustic Source Specifications

Seismic Airguns

The Langseth will deploy a 36-airgun array, with a total volume of approximately 6,600 cubic inches (in³) at a tow depth of 9, 12, or 15 m (29.5, 39.4, or 49.2 ft). The airguns are a mixture of Bolt 1500LL and Bolt 1900LLX airguns ranging in size from 40 to 360 in³, with a firing pressure of 1,900 pounds per square inch. The dominant frequency components range from zero to 188 Hertz (Hz). The array configuration consists of four identical linear strings, with 10 airguns on each string. The Langseth's crew will space the first and last airguns 16 m (52 ft) apart from one another. Of the 10 airguns, nine will fire simultaneously while the tenth airgun will serve as a spare. The

crew will turn on the spare airgun in case one of the other airguns fail. The Langseth will distribute the array across an area of approximately 24 by 16 m (78.7 by 52.5 ft) and will tow the array approximately 100 m (328 ft) behind the vessel.

Juan de Fuca Plate Survey: This survey's array tow depth will be 9 m (29.5 ft) for the multichannel seismic survey using the hydrophone streamer and 12 m (39.4 ft) during the survey using the seismometers. During the multichannel seismic survey, each airgun array will emit a pulse at approximately 16-second (s) intervals which corresponds to a shot interval of approximately 37.5 m (123 ft). During the survey using the seismometers, each airgun array will emit a pulse at approximately 200-s intervals which corresponds to a shot interval of approximately 500 m (1,640.4 ft). During firing, the airguns will emit a brief (approximately 0.1 s) pulse of sound; during the intervening periods of operations, the airguns are silent.

Cascadia Thrust Zone Survey: The survey's array tow depth will be 12 m (39.4 ft). During this survey, each airgun array will emit a pulse at approximately 40-s intervals which corresponds to a shot interval of approximately 100 m (328 ft). During firing, the airguns will emit a brief (approximately 0.1 s) pulse of sound; during the intervening periods of operations, the airguns are silent.

Cascadia Subduction Margin Survey: The survey's array tow depth will be 15 m (49.2 ft). During this survey, each airgun array will emit a pulse at approximately 20-s intervals which corresponds to a shot interval of approximately 50 m (164 ft). During firing, the airguns will emit a brief (approximately 0.1 s) pulse of sound; during the intervening periods of operations, the airguns are silent.

Metrics Used in This Document

This section includes a brief explanation of the sound measurements frequently used in the discussions of acoustic effects in this document. Sound pressure is the sound force per unit area, and is usually measured in micropascals (μPa), where 1 pascal (Pa) is the pressure resulting from a force of one newton exerted over an area of one square meter. In this document, we express sound pressure level as the ratio of a measured sound pressure and a reference level. The commonly used reference pressure level in underwater acoustics is 1 μPa , and the units for sound pressure levels are dB re: 1 μPa .

$$\text{Sound pressure level (in decibels (dB))} = 20 \log (\text{pressure/reference pressure})$$

Sound pressure level is an instantaneous measurement and can be expressed as the peak, the peak-peak (p-p), or the root mean square. Root mean square, which is the square root of the arithmetic average of the squared instantaneous pressure values, is typically used in discussions of the effects of sounds on vertebrates and all references to sound pressure level in this document refer to the root mean square unless otherwise noted. Sound pressure level does not take the duration of a sound into account.

Characteristics of the Airgun Pulses

Airguns function by venting high-pressure air into the water which creates an air bubble. The pressure signature of an individual airgun consists of a sharp rise and then fall in pressure, followed by several positive and negative pressure excursions caused by the oscillation of the resulting air bubble. The oscillation of the air bubble transmits sounds downward through the seafloor and the amount of sound transmitted in the near horizontal directions is reduced. However, the airgun array also emits sounds that travel horizontally toward non-target areas.

The nominal source levels of the airgun array used by the Observatory on the

Langseth is 236 to 265 dB re: 1 $\mu\text{Pa}_{(\text{p-p})}$ and the root mean square value for a given airgun pulse is typically 16 dB re: 1 μPa lower than the peak-to-peak value (Greene, 1997; McCauley et al., 1998, 2000a). However, the difference between root mean square and peak or peak-to-peak values for a given pulse depends on the frequency content and duration of the pulse, among other factors.

Accordingly, the Observatory has predicted the received sound levels in relation to distance and direction from the 36-airgun array and the single Bolt 1900LL 40-in³ airgun, which will be used during power downs. Appendix A of the Foundation's Environmental Assessment provides a detailed description of the modeling for marine seismic source arrays for species mitigation and Appendix B(3) of the Assessment discusses the characteristics of the airgun pulses. These are the source levels applicable to downward propagation. The effective source levels for horizontal propagation are lower than those for downward propagation because of the directional nature of the sound from the airgun array. Refer to the authorization application and Assessment for additional information.

Predicted Sound Levels for the Airguns

Tolstoy et al., (2009) reported results for propagation measurements of pulses from the Langseth's 36-airgun, 6,600 in³ array in shallow-water (approximately 50 m (164 ft)) and deep-water depths (approximately 1,600 m (5,249 ft)) in the Gulf of Mexico in 2007 and 2008. Results of the Gulf of Mexico calibration study (Tolstoy et al., 2009) showed that radii around the airguns for various received levels varied with water depth and that sound propagation varied with array tow depth.

The Observatory used the results from the Gulf of Mexico study to determine the algorithm for its model that calculates the exclusion zones for the 36-airgun array and the

single airgun. These values designate mitigation zones and the Observatory uses them to estimate take (described in greater detail in Section VII of the application and Section IV of the Foundation’s Environmental Assessment) for marine mammals.

Comparison of the Tolstoy et al. (2009) calibration study with the Observatory’s model for the Langseth’s 36-airgun array indicated that the model represents the actual received levels, within the first few kilometers and the locations of the predicted exclusions zones. However, the model for deep water (greater than 1,000 m; 3,280 ft) overestimated the received sound levels at a given distance but is still valid for defining exclusion zones at various tow depths. Because the tow depth of the array in the calibration study is less shallow (6 m; 19.7 ft) than the tow depths in the proposed surveys (9, 12, or 15 m; 29.5, 39.4, or 49.2 ft), the Observatory used the following correction factors for estimating the received levels during the proposed surveys (see Table 1). The correction factors are the ratios of the 160-,180-, and 190-dB distances from the modeled results for the 6,600 in³ airgun array towed at 6 m (19.7 ft) versus 9, 12, or 15 m (29.5, 39.4, or 49.2 ft) (LGL, 2008).

Table 1. Correction factors for estimating the received levels for three proposed surveys in the northeast Pacific Ocean, during June-July, 2012.

Array Tow Depth	160-dB	180-dB	190-dB
9	1.285	1.338	1.364
12	1.467	1.577	1.545
15	1.647	1.718	1.727

For a single airgun, the tow depth has minimal effect on the maximum near-field output and the shape of the frequency spectrum for the single airgun; thus, the predicted exclusion zones are essentially the same at different tow depths. The Observatory’s model does not allow for bottom interactions, and thus is most directly applicable to deep

water.

Table 2 summarizes the predicted distances at which one would expect to receive three sound levels (160-, 180-, and 190-dB) from the 36-airgun array and a single airgun.

To avoid the potential for injury or permanent physiological damage (Level A harassment), we (NMFS, 1995, 2000), we have concluded that cetaceans and pinnipeds should not be exposed to pulsed underwater noise at received levels exceeding 180 dB re: 1 μ Pa and 190 dB re: 1 μ Pa, respectively. The 180-dB and 190-dB level shutdown criteria are applicable to cetaceans and pinnipeds, respectively, specified by us (NMFS, 1995, 2000). The Observatory used these levels to establish the exclusion zones. We also assume that marine mammals exposed to levels exceeding 160 dB re: 1 μ Pa may experience Level B harassment.

Table 2. Measured (array) or predicted (single airgun) distances to which sound levels greater than or equal to 160, 180, and 190 dB re: 1 μ Pa that could be received during the three proposed surveys in the northeast Pacific Ocean, during June-July, 2012.

Source and Volume (in ³)	Tow Depth (m)	Water Depth (m)	Predicted RMS Distances ² (m)		
			160 dB	180 dB	190 dB
Single Bolt airgun (40 in ³)	6-15 ¹	> 1,000	385	40	12
		100 to 1,000	578	60	18
		< 100	1,050	296	150
36-Airgun Array (6,600 in ³)	9	> 1,000	3,850	940	400
		100 to 1,000	12,200	1,540	550
		< 100	20,550	2,140	680
36-Airgun Array (6,600 in ³)	12	> 1,000	4,400	1,100	460
		100 to 1,000	13,935	1,810	615
		< 100	23,470	2,250	770
36-Airgun Array (6,600 in ³)	15	> 1,000	4,490	1,200	520
		100 to 1,000	15,650	1,975	690
		< 100	26,350	2,750	865

¹ For a single airgun, the tow depth has minimal effect on the maximum near-field output and the shape of the frequency spectrum for the single airgun; thus, the predicted exclusion zones are essentially the same at different tow depths.

² The Observatory has based the radii for the array on data in Tolstoy *et al.* (2009) and has corrected for tow depth using modeled results. They have based the predicted radii for a single airgun upon their model (see Figure 3 in application #1).

Ocean Bottom Seismometers

The Observatory proposes to use the Woods Hole Oceanographic Institution “D2” seismometer during the cruise. The seismometer is approximately one meter in height and has a maximum diameter of 50 centimeters (cm). The anchor (2.5 x 30.5 x 38.1 cm) is hot-rolled steel and weighs 23 kilograms. The acoustic release transponder, located on the vessel, communicates with the seismometer at a frequency of 9 to 11 kilohertz (kHz). The source level of the release signal is 190 dB re: 1 μ Pa. The received signal activates the seismometer’s burn-wire release assembly which then releases the seismometer from the anchor. The seismometer then floats to the ocean surface for retrieval by the Oceanus.

Multibeam Echosounder

The Langseth will operate a Kongsberg EM 122 multibeam echosounder concurrently during airgun operations to map characteristics of the ocean floor. The hull-mounted echosounder emits brief pulses of sound (also called a ping) (10.5 to 13 kHz) in a fan-shaped beam that extends downward and to the sides of the ship. The transmitting beamwidth is 1 or 2° fore-aft and 150° athwartship and the maximum source level is 242 dB re: 1 μ Pa.

For deep-water operations, each ping consists of eight (in water greater than 1,000 m; 3,280 ft) or four (less than 1,000 m; 3,280 ft) successive, fan-shaped transmissions, from two to 15 milliseconds (ms) in duration and each ensonifying a sector that extends 1° fore-aft. Continuous wave pulses increase from 2 to 15 ms long in water depths up to 2,600 m (8,530 ft). The echosounder uses frequency-modulated chirp pulses up to 100-

ms long in water greater than 2,600 m (8,530 ft). The successive transmissions span an overall cross-track angular extent of about 150°, with 2-ms gaps between the pulses for successive sectors.

Sub-bottom Profiler

The Langseth will also operate a Knudsen Chirp 3260 sub-bottom profiler concurrently during airgun and echosounder operations to provide information about the sedimentary features and bottom topography. The profiler is capable of reaching depths of 10,000 m (6.2 mi). The dominant frequency component is 3.5 kHz and a hull-mounted transducer on the vessel directs the beam downward in a 27° cone. The power output is 10 kilowatts (kW), but the actual maximum radiated power is three kilowatts or 222 dB re: 1 µPa. The ping duration is up to 64 ms with a pulse interval of one second, but a common mode of operation is to broadcast five pulses at 1-s intervals followed by a 5-s pause.

We expect that acoustic stimuli resulting from the proposed operation of the single airgun or the 36-airgun array has the potential to harass marine mammals, incidental to the conduct of the proposed seismic survey. We also expect these disturbances to be temporary and result in a temporary modification in behavior and/or low-level physiological effects (Level B harassment only) of small numbers of certain species of marine mammals.

We do not expect that the movement of the Langseth, during the conduct of the seismic survey, has the potential to harass marine mammals because of the relatively slow operation speed of the vessel (4.6 kts; 8.5 km/hr; 5.3 mph) during seismic acquisition.

Description of the Marine Mammals in the Area of the Specified Activity

Thirty-one marine mammal species under our jurisdiction may occur in the proposed survey areas, including 19 odontocetes (toothed cetaceans), seven mysticetes (baleen whales), and five species of pinniped during June through July, 2012. Six of these species and two stocks are listed as endangered under the Endangered Species Act of 1973 (ESA; 16 U.S.C. 1531 *et seq.*), including the blue (Balaenoptera musculus), fin (Balaenoptera physalus), humpback (Megaptera novaeangliae), north Pacific right (Eubalaena japonica), sei (Balaenoptera borealis), and sperm (Physeter macrocephalus) whales; the southern resident stock of killer (Orcinus orca) whales; and the eastern U.S. stock of the Steller sea lion (Eumetopias jubatus).

The U.S. Fish and Wildlife Service manages the northern sea otter (Enhydra lutis) (listed under the Endangered Species Act). Because this species is not under our jurisdiction, we do not consider this species further in this notice.

Based on available data, the Observatory does not expect to encounter five of the 31 species in the proposed survey areas. They include the: the north Pacific right, false killer (Pseudorca crassidens), and short-finned pilot (Globicephala macrorhynchus) whales; the California sea lion (Zalophus californianus); and the bottlenose dolphin (Tursiops truncatus) because of these species' rare and/or extralimital occurrence in the survey areas. Accordingly, we did not consider these species in greater detail and the proposed authorization will only address requested take authorizations for 26 species: six mysticetes, 16 odontocetes, and four species of pinniped.

Of these 26 species, the most common marine mammals in the survey area would be

the: harbor porpoise (Phocoena phocoena), Dall's porpoise (Phocoenoides dalli), northern fur seal (Callorhinus ursinus), and northern elephant seal (Mirounga angustirostris).

Table 3 presents information on the abundance, distribution, and conservation status of the marine mammals that may occur in the proposed survey area June through July, 2012.

Table 3. Habitat, abundance, density, and ESA status of marine mammals that may occur in or near the proposed seismic survey areas in the northeast Pacific Ocean. [See text and Tables 2 and 3 in the Observatory's applications and the Foundation's Environmental Assessment for further details.]

Species	Occurrence in Area	Habitat	Abundance in the NW Pacific ¹	ESA ²	Density ³ #/1,000 km ²
Mysticetes					
North Pacific right whale	Rare	Coastal, shelf, offshore	31 ⁴	EN	0
Gray whale	Common*	Coastal, shallow shelf	19,126 ⁵	DL	3.21
Humpback whale	Common*	Mainly nearshore and banks	20,800 ⁶	EN	0.81
Minke whale	Rare	Nearshore, offshore	9,000 ⁷	NL	0.46
Sei whale	Rare	Mostly pelagic	12,620 ⁸	EN	0.16
Fin whale	Common	Slope, pelagic	13,620–18,680 ⁹	EN	1.29
Blue whale	Rare	Pelagic and coastal	2,497	EN	0.18
Odontocetes					
Sperm whale	Common	Pelagic, steep topography	24,000 ¹⁰	EN	1.02
Pygmy sperm whale	Rare	Deep, off shelf	N.A.	NL	0.71
Dwarf sperm whale	Rare	Deep, shelf, slope	N.A.	NL	0.71
Cuvier's beaked whale	Common	Pelagic	2,143	NL	0.43
Baird's beaked whale	Common	Pelagic	907	NL	1.18
Blainville's beaked whale	Rare	Pelagic	1,024 ¹¹	NL	1.75
Hubb's beaked whale	Rare	Slope, offshore	1,024 ¹¹	NL	1.75
Stejneger's beaked whale	Common	Slope, offshore	1,024 ¹¹	NL	1.75
Common bottlenose dolphin	Rare	Coastal, shelf, deep	1,006 ¹²	NL	0
Striped dolphin	Rare	Off continental shelf	10,908	NL	0.04
Short-beaked common dolphin	Common	Shelf, pelagic, mounts	411,211	NL	10.28
Pacific white-sided dolphin	Abundant	Offshore, slope	26,930	NL	34.91
Northern right whale dolphin	Common	Slope, offshore waters	8,334	NL	12.88
Risso's dolphin	Common	Shelf, slope, mounts	6,272	NL	11.19
False killer whale	Rare	Pelagic	N.A.	NL	0
Killer whale	Common	Widely distributed	2,250–2,700	NL/EN ¹³	1.66
Short-finned pilot whale	Rare	Pelagic, high-relief	760	NL	0
Harbor porpoise	Abundant	Coastal and inland waters	55,255 ¹³	NL	632.4
Dall's porpoise	Abundant	Shelf, slope, offshore	42,000	NL	83.82
Pinnipeds					
Northern fur seal	Common	Pelagic, offshore	653,171 ⁵	NL	83.62

Species	Occurrence in Area	Habitat	Abundance in the NW Pacific¹	ESA²	Density³ #/1,000 km²
California sea lion	Rare	Coastal, shelf	296,750	NL	0
Steller sea lion	Common*	Coastal, shelf	58,334–72,223 ⁵	T	13.12
Harbor seal	Abundant*	Coastal	24,732 ¹⁴	NL	292.3
Northern elephant seal	Common	Coastal, pelagic in migration	124,000 ¹⁵	NL	45.81

N.A. - Data not available or species status was not assessed.

* In nearshore survey areas, rare elsewhere.

¹ Abundance given for the California/Oregon/Washington or Eastern North Pacific stock (Carretta et al. 2011a,b), unless otherwise stated.

² Endangered Species Act: EN = Endangered, T = Threatened, DL = Delisted, NL = Not listed

³ Density estimate as listed in Table 3 of the Observatory's applications. Refer to pg. 48 of application #1, pg. 47 of application #2, and pg. 47 of application #3 for specific references.

⁴ Bering Sea (Wade et al. 2010)

⁵ Eastern North Pacific (Allen and Angliss 2011)

⁶ North Pacific (Barlow et al. 2009)

⁷ North Pacific (Wada 1976)

⁸ North Pacific (Tillman 1977)

⁹ North Pacific (Ohsumi and Wada 1974)

¹⁰ Eastern Temperate North Pacific (Whitehead 2002a)

¹¹ All mesoplodont whales

¹² Offshore stock (Carretta et al. 2011a)

¹³ The Eastern North Pacific Southern Resident Stock of killer whales is listed as Endangered under the ESA.

¹⁴ Northern Oregon/Washington Coast and Northern California/Southern Oregon stocks

¹⁵ Oregon/Washington Coastal Stock (Carretta et al. 2011a)

Refer to Sections III and IV of the Observatory's applications for detailed information regarding the abundance and distribution, population status, and life history and behavior of these species and their occurrence in the proposed project area. The applications also present how the Observatory calculated the estimated densities for the marine mammals in the proposed survey area. We have reviewed these data and determined them to be the best available scientific information for the purposes of the proposed incidental harassment authorization.

Potential Effects on Marine Mammals

Acoustic stimuli generated by the operation of the airguns, which introduce sound into the marine environment, may have the potential to cause Level B harassment of marine mammals in the proposed survey area. The effects of sounds from airgun operations might include one or more of the following: tolerance, masking of natural

sounds, behavioral disturbance, temporary or permanent impairment, or non-auditory physical or physiological effects (Richardson et al., 1995; Gordon et al., 2004; Nowacek et al., 2007; Southall et al., 2007).

Permanent hearing impairment, in the unlikely event that it occurred, would constitute injury, but temporary threshold shift is not an injury (Southall et al., 2007). Although we cannot exclude the possibility entirely, it is unlikely that the proposed project would result in any cases of temporary or permanent hearing impairment, or any significant non-auditory physical or physiological effects. Based on the available data and studies described in this document, we expect some behavioral disturbance, but we expect the disturbance to be localized.

Tolerance

Studies on marine mammals' tolerance to sound in the natural environment are relatively rare. Richardson et al. (1995) defined tolerance as the occurrence of marine mammals in areas where they are exposed to human activities or manmade noise. In many cases, tolerance develops by the animal habituating to the stimulus (i.e., the gradual waning of responses to a repeated or ongoing stimulus) (Richardson, et al., 1995; Thorpe, 1963), but because of ecological or physiological requirements, many marine animals may need to remain in areas where they are exposed to chronic stimuli (Richardson, et al., 1995).

Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers. Several studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response (see Appendix B(5) in the Environmental Assessment).

That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of the marine mammal group. Although various baleen whales and toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to airgun pulses under some conditions, at other times marine mammals of all three types have shown no overt reactions (Stone, 2003; Stone and Tasker, 2006; Moulton et al. 2005, 2006a; Weir 2008a for sperm whales), (MacLean and Koski, 2005; Bain and Williams, 2006 for Dall's porpoises). The relative responsiveness of baleen and toothed whales are quite variable.

Masking of Natural Sounds

The term masking refers to the inability of a subject to recognize the occurrence of an acoustic stimulus as a result of the interference of another acoustic stimulus (Clark et al., 2009). Introduced underwater sound may, through masking, reduce the effective communication distance of a marine mammal species if the frequency of the source is close to that used as a signal by the marine mammal, and if the anthropogenic sound is present for a significant fraction of the time (Richardson et al., 1995).

We expect that the masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds will be limited, although there are very few specific data on this. Because of the intermittent nature and low duty cycle of seismic airgun pulses, animals can emit and receive sounds in the relatively quiet intervals between pulses. However, in some situations, reverberation occurs for much or the entire interval between pulses (e.g., Simard et al., 2005; Clark and Gagnon, 2006) which could mask calls. We understand that some baleen and toothed whales continue calling in the presence of seismic pulses, and that some researchers have heard these calls

between the seismic pulses (e.g., Richardson et al., 1986; McDonald et al., 1995; Greene et al., 1999; Niekirk et al., 2004; Smultea et al., 2004; Holst et al., 2005a,b, 2006; and Dunn and Hernandez, 2009). However, Clark and Gagnon (2006) reported that fin whales in the northeast Pacific Ocean went silent for an extended period starting soon after the onset of a seismic survey in the area. Similarly, there has been one report that sperm whales ceased calling when exposed to pulses from a very distant seismic ship (Bowles et al., 1994). However, more recent studies have found that they continued calling in the presence of seismic pulses (Madsen et al., 2002; Tyack et al., 2003; Smultea et al., 2004; Holst et al., 2006; and Jochens et al., 2008). Several studies have reported hearing dolphins and porpoises calling while airguns were operating (e.g., Gordon et al., 2004; Smultea et al., 2004; Holst et al., 2005a, b; and Potter et al., 2007). The sounds important to small odontocetes are predominantly at much higher frequencies than are the dominant components of airgun sounds, thus limiting the potential for masking.

In general, we expect that the masking effects of seismic pulses will be minor, given the normally intermittent nature of seismic pulses. Refer to Appendix B(4) of the Foundation's Assessment for a more detailed discussion of masking effects on marine mammals.

Behavioral Disturbance

Disturbance includes a variety of effects, including subtle to conspicuous changes in behavior, movement, and displacement. Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors (Richardson et al., 1995; Wartzok et al., 2004; Southall et al., 2007;

Weilgart, 2007). If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (e.g., Lusseau and Bejder, 2007; Weilgart, 2007). Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many mammals would be present within a particular distance of industrial activities and/or exposed to a particular level of industrial sound. In most cases, this approach likely overestimates the numbers of marine mammals that would be affected in some biologically-important manner.

The sound criteria used to estimate how many marine mammals might be disturbed to some biologically-important degree by a seismic program are based primarily on behavioral observations of a few species. Scientists have conducted detailed studies on humpback, gray, bowhead (Balaena mysticetus), and sperm whales. There are less detailed data available for some other species of baleen whales, small toothed whales, and sea otters (Enhydra lutris), but for many species there are no data on responses to marine seismic surveys.

Baleen Whales—Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable (reviewed in Richardson et al., 1995). Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, as reviewed in Appendix B(5) of the

Foundation's Assessment, baleen whales exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away from the area. In the cases of migrating gray and bowhead whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals (Richardson et al., 1995). They avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors.

Studies of gray, bowhead, and humpback whales have shown that seismic pulses with received levels of 160 to 170 dB re: 1 μ Pa seem to cause obvious avoidance behavior in a substantial fraction of the animals exposed (Malme et al., 1986, 1988; Richardson et al., 1995). In many areas, seismic pulses from large arrays of airguns diminish to those levels at distances ranging from four to 15 km (2.5 to 9.3 mi) from the source. A substantial proportion of the baleen whales within those distances may show avoidance or other strong behavioral reactions to the airgun array. Subtle behavioral changes sometimes become evident at somewhat lower received levels, and studies summarized in Appendix B(5) of the Foundation's Assessment have shown that some species of baleen whales, notably bowhead and humpback whales, at times show strong avoidance at received levels lower than 160–170 dB re: 1 μ Pa.

Researchers have studied the responses of humpback whales to seismic surveys during migration, feeding during the summer months, breeding while offshore from Angola, and wintering offshore from Brazil. McCauley et al. (1998, 2000a) studied the responses of humpback whales off western Australia to a full-scale seismic survey with a 16-airgun array (2,678-in³) and to a single, 20-in³ airgun with source level of 227 dB re: 1

μPa (p-p). In the 1998 study, the researchers documented that avoidance reactions began at five to eight km (3.1 to 4.9 mi) from the array, and that those reactions kept most pods approximately three to four km (1.9 to 2.5 mi) from the operating seismic boat. In the 2000 study, McCauley *et al.* noted localized displacement during migration of four to five km (2.5 to 3.1 mi) by traveling pods and seven to 12 km (4.3 to 7.5 mi) by more sensitive resting pods of cow-calf pairs. Avoidance distances with respect to the single airgun were smaller but consistent with the results from the full array in terms of the received sound levels. The mean received level for initial avoidance of an approaching airgun was 140 dB re: 1 μPa for humpback pods containing females, and at the mean closest point of approach distance, the received level was 143 dB re: 1 μPa . The initial avoidance response generally occurred at distances of five to eight km (3.1 to 4.9 mi) from the airgun array and two km (1.2 mi) from the single airgun. However, some individual humpback whales, especially males, approached within distances of 100 to 400 m (328 to 1,312 ft), where the maximum received level was 179 dB re: 1 μPa .

Data collected by observers during several seismic surveys in the northwest Atlantic Ocean showed that sighting rates of humpback whales were significantly greater during non-seismic periods compared with periods when a full array was operating (Moulton and Holst, 2010). In addition, humpback whales were more likely to swim away and less likely to swim towards a vessel during seismic versus non-seismic periods (Moulton and Holst, 2010).

Humpback whales on their summer feeding grounds in Frederick Sound and Stephens Passage, Alaska did not exhibit persistent avoidance when exposed to seismic pulses from a 1.64-L (100-in³) airgun (Malme *et al.*, 1985). Some humpbacks seemed “startled”

at received levels of 150 to 169 dB re: 1 μ Pa. Malme *et al.* (1985) concluded that there was no clear evidence of avoidance, despite the possibility of subtle effects, at received levels up to 172 re: 1 μ Pa.

Other studies have suggested that south Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys (Engel *et al.*, 2004). Although, the evidence for this was circumstantial and subject to alternative explanations (IAGC, 2004). Also, the evidence was not consistent with subsequent results from the same area of Brazil (Parente *et al.*, 2006), or with direct studies of humpbacks exposed to seismic surveys in other areas and seasons. After allowance for data from subsequent years, there was “no observable direct correlation” between strandings and seismic surveys (IWC, 2007: 236).

There are no data on reactions of right whales to seismic surveys, but results from the closely-related bowhead whale show that their responsiveness can be quite variable depending on their activity (migrating versus feeding). Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with substantial avoidance occurring out to distances of 20 to 30 km (12.4 to 18.6 mi) from a medium-sized airgun source at received sound levels of approximately 120 to 130 dB re: 1 μ Pa (Miller *et al.*, 1999; Richardson *et al.*, 1999; see Appendix B(5) of the Foundation’s Assessment). However, more recent research on bowhead whales (Miller *et al.*, 2005; Harris *et al.*, 2007) corroborates earlier evidence that, during the summer feeding season, bowheads are not as sensitive to seismic sources. Nonetheless, subtle but statistically significant changes in surfacing–respiration–dive cycles were evident upon statistical analysis (Richardson *et al.*, 1986). In the summer, bowheads typically begin to

show avoidance reactions at received levels of about 152 to 178 dB re: 1 μ Pa (Richardson et al., 1986, 1995; Ljungblad et al., 1988; Miller et al., 2005).

A few studies have documented reactions of migrating and feeding (but not wintering) gray whales to seismic surveys. Malme et al. (1986, 1988) studied the responses of feeding eastern Pacific gray whales to pulses from a single 100-in³ airgun off St. Lawrence Island in the northern Bering Sea. They estimated, based on small sample sizes, that 50 percent of feeding gray whales stopped feeding at an average received pressure level of 173 dB re: 1 μ Pa on an (approximate) root mean square basis, and that 10 percent of feeding whales interrupted feeding at received levels of 163 dB re: 1 μ Pa. Those findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast (Malme et al., 1984; Malme and Miles, 1985), and western Pacific gray whales feeding off Sakhalin Island, Russia (Wursig et al., 1999; Gailey et al., 2007; Johnson et al., 2007; Yazvenko et al., 2007a,b), along with data on gray whales off British Columbia (Bain and Williams, 2006).

Occasionally, observers have seen various species of Balaenoptera (blue, sei, fin, and minke whales) in areas ensonified by airgun pulses (Stone, 2003; MacLean and Haley, 2004; Stone and Tasker, 2006), and have localized calls from blue and fin whales in areas with airgun operations (e.g., McDonald et al., 1995; Dunn and Hernandez, 2009; Castellote et al., 2010). Sightings by observers on seismic vessels off the United Kingdom from 1997 to 2000 suggest that, during times of good sightability, sighting rates for mysticetes (mainly fin and sei whales) were similar when large arrays of airguns were shooting vs. silent (Stone, 2003; Stone and Tasker, 2006). However, these whales tended

to exhibit localized avoidance, remaining significantly further (on average) from the airgun array during seismic operations compared with non-seismic periods (Stone and Tasker, 2006). Castellote et al. (2010) also observed localized avoidance by fin whales during seismic airgun events in the western Mediterranean Sea and adjacent Atlantic waters from 2006–2009. They reported that singing fin whales moved away from an operating airgun array for a time period that extended beyond the duration of the airgun activity.

Ship-based monitoring studies of baleen whales (including blue, fin, sei, minke, and whales) in the northwest Atlantic found that overall, this group had lower sighting rates during seismic versus non-seismic periods (Moulton and Holst, 2010). Baleen whales as a group were also seen significantly farther from the vessel during seismic compared with non-seismic periods, and they were more often seen to be swimming away from the operating seismic vessel (Moulton and Holst, 2010). Blue and minke whales were initially sighted significantly farther from the vessel during seismic operations compared to non-seismic periods; the same trend was observed for fin whales (Moulton and Holst, 2010). Minke whales were most often observed to be swimming away from the vessel when seismic operations were underway (Moulton and Holst, 2010).

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. We do not know whether impulsive sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America with substantial increases in the population over recent years, despite intermittent seismic exploration (and much ship traffic) in that area for decades

(Appendix A in Malme et al., 1984; Richardson et al., 1995; Allen and Angliss, 2011).

The western Pacific gray whale population did not appear affected by a seismic survey in its feeding ground during a previous year (Johnson et al., 2007). Similarly, bowhead whales have continued to travel to the eastern Beaufort Sea each summer, and their numbers have increased notably, despite seismic exploration in their summer and autumn range for many years (Richardson et al., 1987; Allen and Angliss, 2011).

Toothed Whales—There is little systematic information available about reactions of toothed whales to noise pulses. There are few studies on toothed whales similar to the more extensive baleen whale/seismic pulse work summarized earlier in Appendix B of the Foundation’s Assessment. However, there are recent systematic studies on sperm whales (e.g., Gordon et al., 2006; Madsen et al., 2006; Winsor and Mate, 2006; Jochens et al., 2008; Miller et al., 2009). There is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies (e.g., Stone, 2003; Smultea et al., 2004; Moulton and Miller, 2005; Bain and Williams, 2006; Holst et al., 2006; Stone and Tasker, 2006; Potter et al., 2007; Hauser et al., 2008; Holst and Smultea, 2008; Weir, 2008; Barkaszi et al., 2009; Richardson et al., 2009; Moulton and Holst, 2010).

Seismic operators and protected species observers (observers) on seismic vessels regularly see dolphins and other small toothed whales near operating airgun arrays, but in general there is a tendency for most delphinids to show some avoidance of operating seismic vessels (e.g., Goold, 1996a,b,c; Calambokidis and Osmeck, 1998; Stone, 2003; Moulton and Miller, 2005; Holst et al., 2006; Stone and Tasker, 2006; Weir, 2008; Richardson et al., 2009; Barkaszi et al., 2009; Moulton and Holst, 2010). Some dolphins

seem to be attracted to the seismic vessel and floats, and some ride the bow wave of the seismic vessel even when large arrays of airguns are firing (e.g., Moulton and Miller, 2005). Nonetheless, small toothed whales more often tend to head away, or to maintain a somewhat greater distance from the vessel, when a large array of airguns is operating than when it is silent (e.g., Stone and Tasker, 2006; Weir, 2008, Barry et al., 2010; Moulton and Holst, 2010). In most cases, the avoidance radii for delphinids appear to be small, on the order of one km or less, and some individuals show no apparent avoidance. The beluga whale (Delphinapterus leucas) is a species that (at least at times) shows long-distance avoidance of seismic vessels. Summer aerial surveys conducted in the southeastern Beaufort Sea reported that sighting rates of beluga whales were significantly lower at distances of 10 to 20 km (6.2 to 12.4 mi) from an operating airgun array compared to distances of 20 to 30 km (12.4 to 18.6 mi). Further, observers on seismic boats in that area have rarely reported sighting beluga whales (Miller et al., 2005; Harris et al., 2007).

Captive bottlenose dolphins (Tursiops truncatus) and beluga whales exhibited changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys (Finneran et al., 2000, 2002, 2005). However, the animals tolerated high received levels of sound before exhibiting aversive behaviors.

Results for porpoises depend on species. The limited available data suggest that harbor porpoises (Phocoena phocoena) show stronger avoidance of seismic operations than do Dall's porpoises (Stone, 2003; MacLean and Koski, 2005; Bain and Williams, 2006; Stone and Tasker, 2006). Dall's porpoises seem relatively tolerant of airgun operations (MacLean and Koski, 2005; Bain and Williams, 2006), although they too have

been observed to avoid large arrays of operating airguns (Calambokidis and Osmek, 1998; Bain and Williams, 2006). This apparent difference in responsiveness of these two porpoise species is consistent with their relative responsiveness to boat traffic and some other acoustic sources (Richardson et al., 1995; Southall et al., 2007).

Most studies of sperm whales exposed to airgun sounds indicate that the whale shows considerable tolerance of airgun pulses (e.g., Stone, 2003; Moulton et al., 2005, 2006a; Stone and Tasker, 2006; Weir, 2008). In most cases the whales do not show strong avoidance, and they continue to call (see Appendix B of the Foundation's Assessment for review). However, controlled exposure experiments in the Gulf of Mexico indicate that foraging behavior was altered upon exposure to airgun sound (Jochens et al., 2008; Miller et al., 2009; Tyack, 2009).

There are almost no specific data on the behavioral reactions of beaked whales to seismic surveys. However, some northern bottlenose whales (Hyperoodon ampullatus) remained in the general area and continued to produce high-frequency clicks when exposed to sound pulses from distant seismic surveys (Gosselin and Lawson, 2004; Laurinolli and Cochrane, 2005; Simard et al., 2005). Most beaked whales tend to avoid approaching vessels of other types (e.g., Wursig et al., 1998). They may also dive for an extended period when approached by a vessel (e.g., Kasuya, 1986), although it is uncertain how much longer such dives may be as compared to dives by undisturbed beaked whales, which also are often quite long (Baird et al., 2006; Tyack et al., 2006). Based on a single observation, Aguilar-Soto et al. (2006) suggested that foraging efficiency of Cuvier's beaked whales (Ziphius cavirostris) may be reduced by close approach of vessels. In any event, it is likely that most beaked whales would also show

strong avoidance of an approaching seismic vessel, although this has not been documented explicitly. In fact, Moulton and Holst (2010) reported 15 sightings of beaked whales during seismic studies in the Northwest Atlantic; seven of those sightings were made at times when at least one airgun was operating. There was little evidence to indicate that beaked whale behavior was affected by airgun operations; sighting rates and distances were similar during seismic and non-seismic periods (Moulton and Holst, 2010).

There are increasing indications that some beaked whales tend to strand when naval exercises involving mid-frequency sonar operation are underway within the vicinity of the animals (e.g., Simmonds and Lopez-Jurado, 1991; Frantzis, 1998; NOAA and USN, 2001; Jepson et al., 2003; Hildebrand, 2005; Barlow and Gisiner, 2006; see also the Stranding and Mortality section in this notice). These strandings are apparently a disturbance response, although auditory or other injuries or other physiological effects may also be involved. Whether beaked whales would ever react similarly to seismic surveys is unknown. Seismic survey sounds are quite different from those of the sonar in operation during the above-cited incidents.

Odontocete reactions to large arrays of airguns are variable and, at least for delphinids and Dall's porpoises, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes, belugas, and harbor porpoises (See Appendix B of the Foundation's Assessment).

Pinnipeds—Pinnipeds are not likely to show a strong avoidance reaction to the airgun array. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behavior, see Appendix B(5)(3)

of the Foundation's Assessment. In the Beaufort Sea, some ringed seals avoided an area of 100 m (328 ft) to (at most) a few hundred meters around seismic vessels, but many seals remained within 100 to 200 m (328 to 656 ft) of the trackline as the operating airgun array passed by (e.g., Harris et al., 2001; Moulton and Lawson, 2002; Miller et al., 2005). Ringed seal sightings averaged somewhat farther away from the seismic vessel when the airguns were operating than when they were not, but the difference was small (Moulton and Lawson, 2002). Similarly, in Puget Sound, sighting distances for harbor seals and California sea lions tended to be larger when airguns were operating (Calambokidis and Osmeck, 1998). Previous telemetry work suggests that avoidance and other behavioral reactions may be stronger than evident to date from visual studies (Thompson et al., 1998).

Hearing Impairment and Other Physical Effects

Exposure to high intensity sound for a sufficient duration may result in auditory effects such as a noise-induced threshold shift—an increase in the auditory threshold after exposure to noise (Finneran et al., 2005). Factors that influence the amount of threshold shift include the amplitude, duration, frequency content, temporal pattern, and energy distribution of noise exposure. The magnitude of hearing threshold shift normally decreases over time following cessation of the noise exposure. The amount of threshold shift just after exposure is called the initial threshold shift. If the threshold shift eventually returns to zero (i.e., the threshold returns to the pre-exposure value), it is called temporary threshold shift (Southall et al., 2007).

Researchers have studied temporary threshold shift in certain captive odontocetes and pinnipeds exposed to strong sounds (reviewed in Southall et al., 2007). However, there

has been no specific documentation of temporary threshold shift let alone permanent hearing damage, i.e., permanent threshold shift, in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions.

Temporary Threshold Shift—This is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter, 1985). While experiencing temporary threshold shift, the hearing threshold rises and a sound must be stronger in order to be heard. At least in terrestrial mammals, temporary threshold shift can last from minutes or hours to (in cases of strong shifts) days. For sound exposures at or somewhat above the temporary threshold shift threshold, hearing sensitivity in both terrestrial and marine mammals recovers rapidly after exposure to the noise ends. There are few data on sound levels and durations necessary to elicit mild temporary threshold shift for marine mammals, and none of the published data focus on temporary threshold shift elicited by exposure to multiple pulses of sound. Southall et al. (2007) summarizes available data on temporary threshold shift in marine mammals. Table 2 (introduced earlier in this document) presents the estimated distances from the Langseth's airguns at which the received energy level (per pulse, flat-weighted) would be greater than or equal to 180 or 190 dB re: 1 μ Pa.

Researchers have derived temporary threshold shift information for odontocetes from studies on the bottlenose dolphin and beluga. For the one harbor porpoise tested, the received level of airgun sound that elicited onset of temporary threshold shift was lower (Lucke et al., 2009). If these results from a single animal are representative, it is inappropriate to assume that onset of temporary threshold shift occurs at similar received levels in all odontocetes (cf. Southall et al., 2007). Some cetaceans apparently can incur

temporary threshold shift at considerably lower sound exposures than are necessary to elicit temporary threshold shift in the beluga or bottlenose dolphin.

For baleen whales, there are no data, direct or indirect, on levels or properties of sound that are required to induce temporary threshold shift. The frequencies to which baleen whales are most sensitive are assumed to be lower than those to which odontocetes are most sensitive, and natural background noise levels at those low frequencies tend to be higher. As a result, auditory thresholds of baleen whales within their frequency band of best hearing are believed to be higher (less sensitive) than are those of odontocetes at their best frequencies (Clark and Ellison, 2004). From this, it is suspected that received levels causing temporary threshold shift onset may also be higher in baleen whales (Southall et al., 2007). For this proposed study, the Observatory expects no cases of temporary threshold shift given the low abundance of baleen whales in the planned study area at the time of the survey, and the strong likelihood that baleen whales would avoid the approaching airguns (or vessel) before being exposed to levels high enough for temporary threshold shift to occur.

In pinnipeds, researchers have not measured temporary threshold shift thresholds associated with exposure to brief pulses (single or multiple) of underwater sound. Initial evidence from more prolonged (non-pulse) exposures suggested that some pinnipeds (harbor seals in particular) incur temporary threshold shift at somewhat lower received levels than do small odontocetes exposed for similar durations (Kastak et al., 1999, 2005; Ketten et al., 2001). The indirectly estimated temporary threshold shift threshold for pulsed sounds would be approximately 181 to 186 dB re: 1 μ Pa (Southall et al., 2007), or a series of pulses for which the highest sound exposure level values are a few decibels

lower. Corresponding values for California sea lions and northern elephant seals are likely to be higher (Kastak et al., 2005).

Permanent Threshold Shift—When permanent threshold shift occurs, there is physical damage to the sound receptors in the ear. In severe cases, there can be total or partial deafness, whereas in other cases, the animal has an impaired ability to hear sounds in specific frequency ranges (Kryter, 1985). There is no specific evidence that exposure to pulses of airgun sound can cause permanent threshold shift in any marine mammal, even with large arrays of airguns. However, given the possibility that mammals close to an airgun array might incur at least mild temporary threshold shift, there has been further speculation about the possibility that some individuals occurring very close to airguns might incur permanent threshold shift (e.g., Richardson et al., 1995, p. 372ff; Gedamke et al., 2008). Single or occasional occurrences of mild temporary threshold shift are not indicative of permanent auditory damage, but repeated or (in some cases) single exposures to a level well above that causing temporary threshold shift onset might elicit permanent threshold shift.

Relationships between temporary threshold shift and permanent threshold shift thresholds have not been studied in marine mammals, but are assumed to be similar to those in humans and other terrestrial mammals. Permanent threshold shift might occur at a received sound level at least several decibels above that inducing mild temporary threshold shift if the animal were exposed to strong sound pulses with rapid rise times—see Appendix B(6) of the Foundation’s Assessment. Based on data from terrestrial mammals, a precautionary assumption is that the permanent threshold shift threshold for impulse sounds (such as airgun pulses as received close to the source) is at least six

decibels higher than the temporary threshold shift threshold on a peak-pressure basis, and probably greater than six decibels (Southall et al., 2007).

Given the higher level of sound necessary to cause permanent threshold shift as compared with temporary threshold shift, it is considerably less likely that permanent threshold shift would occur. Baleen whales generally avoid the immediate area around operating seismic vessels, as do some other marine mammals.

Stranding and Mortality

When a living or dead marine mammal swims or floats onto shore and becomes “beached” or incapable of returning to sea, the event is termed a “stranding” (Geraci et al., 1999; Perrin and Geraci, 2002; Geraci and Lounsbury, 2005; NMFS, 2007). The legal definition for a stranding under the MMPA is that “(A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of apparent medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance”.

Marine mammals are known to strand for a variety of reasons, such as infectious agents, biotoxycosis, starvation, fishery interaction, ship strike, unusual oceanographic or weather events, sound exposure, or combinations of these stressors sustained concurrently or in series. However, the cause or causes of most strandings are unknown (Geraci et al., 1976; Eaton, 1979; Odell et al., 1980; Best, 1982). Numerous studies

suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause them to strand or might pre-dispose them to strand when exposed to another phenomenon. These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Chroussos, 2000; Creel, 2005; DeVries et al., 2003; Fair and Becker, 2000; Foley et al., 2001; Moberg, 2000; Relyea, 2005a; 2005b, Romero, 2004; Sih et al., 2004).

Strandings Associated with Military Active Sonar—Several sources have published lists of mass stranding events of cetaceans in an attempt to identify relationships between those stranding events and military active sonar (Hildebrand, 2004; IWC, 2005; Taylor et al., 2004). For example, based on a review of stranding records between 1960 and 1995, the International Whaling Commission (2005) identified ten mass stranding events and concluded that, out of eight stranding events reported from the mid-1980s to the summer of 2003, seven had been coincident with the use of mid-frequency active sonar and most involved beaked whales.

Over the past 12 years, there have been five stranding events coincident with military mid-frequency active sonar use in which exposure to sonar is believed to have been a contributing factor to strandings: Greece (1996); the Bahamas (2000); Madeira (2000); Canary Islands (2002); and Spain (2006). Refer to Cox et al. (2006) for a summary of common features shared by the strandings events in Greece (1996), Bahamas (2000), Madeira (2000), and Canary Islands (2002); and Fernandez et al., (2005) for an additional summary of the Canary Islands 2002 stranding event.

Potential for Stranding from Seismic Surveys—The association of strandings of beaked whales with naval exercises involving mid-frequency active sonar and, in one case, an Observatory’s seismic survey (Malakoff, 2002; Cox et al., 2006), has raised the possibility that beaked whales exposed to strong “pulsed” sounds may be especially susceptible to injury and/or behavioral reactions that can lead to stranding (e.g., Hildebrand, 2005; Southall et al., 2007). Appendix B (6) of the Foundation’s Assessment provides additional details.

Specific sound-related processes that lead to strandings and mortality are not well documented, but may include:

- (1) Swimming in avoidance of a sound into shallow water;
- (2) A change in behavior (such as a change in diving behavior) that might contribute to tissue damage, gas bubble formation, hypoxia, cardiac arrhythmia, hypertensive hemorrhage or other forms of trauma;
- (3) A physiological change such as a vestibular response leading to a behavioral change or stress-induced hemorrhagic diathesis, leading in turn to tissue damage; and
- (4) Tissue damage directly from sound exposure, such as through acoustically-mediated bubble formation and growth or acoustic resonance of tissues. Some of these mechanisms are unlikely to apply in the case of impulse sounds. However, there are increasing indications that gas-bubble disease (analogous to the bends), induced in supersaturated tissue by a behavioral response to acoustic exposure, could be a pathologic mechanism for the strandings and mortality of some deep-diving cetaceans exposed to sonar. However, the evidence for this remains circumstantial and associated with exposure to naval mid-frequency sonar, not seismic surveys (Cox et al., 2006; Southall et

al., 2007).

Seismic pulses and mid-frequency sonar signals are quite different, and some mechanisms by which sonar sounds have been hypothesized to affect beaked whales are unlikely to apply to airgun pulses. Sounds produced by airgun arrays are broadband impulses with most of the energy below one kHz. Typical military mid-frequency sonar emits non-impulse sounds at frequencies of two to 10 kHz, generally with a relatively narrow bandwidth at any one time. A further difference between seismic surveys and naval exercises is that naval exercises can involve sound sources on more than one vessel. Thus, it is not appropriate to assume that there is a direct connection between the effects of military sonar and seismic surveys on marine mammals. However, evidence that sonar signals can, in special circumstances, lead (at least indirectly) to physical damage and mortality (e.g., Balcomb and Claridge, 2001; NOAA and USN, 2001; Jepson et al., 2003; Fernández et al., 2004, 2005; Hildebrand 2005; Cox et al., 2006) suggests that caution is warranted when dealing with exposure of marine mammals to any high-intensity “pulsed” sound.

There is no conclusive evidence of cetacean strandings or deaths at sea as a result of exposure to seismic surveys, but a few cases of strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings. Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel et al., 2004) were not well founded (IAGC, 2004; IWC, 2007). In September 2002, two Cuvier’s beaked whales stranded in the Gulf of California, Mexico while the Observatory’s R/V Maurice Ewing had been operating a 20-airgun (8,490 in³) array in the general area. The link between the

stranding and the seismic surveys was inconclusive and not based on any physical evidence (Hogarth, 2002; Yoder, 2002). Nonetheless, the Gulf of California incident plus the beaked whale strandings near naval exercises involving use of mid-frequency sonar suggests a need for caution in conducting seismic surveys in areas occupied by beaked whales until more is known about effects of seismic surveys on those species (Hildebrand, 2005). We anticipate no injuries of beaked whales during the proposed study because of:

(1) The likelihood that any beaked whales nearby would avoid the approaching vessel before being exposed to high sound levels; and

(2) Differences between the sound sources operated by the Observatory and those involved in the naval exercises associated with strandings.

Non-auditory Physiological Effects

Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, resonance, and other types of organ or tissue damage (Cox et al., 2006; Southall et al., 2007). Studies examining such effects are limited. However, resonance effects (Gentry, 2002) and direct noise-induced bubble formations (Crum et al., 2005) are implausible in the case of exposure to an impulsive broadband source like an airgun array. If seismic surveys disrupt diving patterns of deep-diving species, this might perhaps result in bubble formation and a form of the bends, as speculated to occur in beaked whales exposed to sonar. However, there is no specific evidence of this upon exposure to airgun pulses.

In general, very little is known about the potential for seismic survey sounds (or other

types of strong underwater sounds) to cause non-auditory physical effects in marine mammals. Such effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. The available data do not allow identification of a specific exposure level above which non-auditory effects can be expected (Southall et al., 2007), or any meaningful quantitative predictions of the numbers (if any) of marine mammals that might be affected in those ways. Marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales and some odontocetes, are especially unlikely to incur non-auditory physical effects.

Potential Effects of Other Acoustic Devices

Multibeam Echosounder

The Observatory will operate the Kongsberg EM 122 multibeam echosounder from the source vessel during the planned study. Sounds from the multibeam echosounder are very short pulses, occurring for two to 15 ms once every five to 20 s, depending on water depth. Most of the energy in the sound pulses emitted by this echosounder is at frequencies near 12 kHz, and the maximum source level is 242 dB re: 1 μ Pa. The beam is narrow (1 to 2°) in fore-aft extent and wide (150°) in the cross-track extent. Each ping consists of eight (in water greater than 1,000 m deep) or four (less than 1,000 m deep) successive fan-shaped transmissions (segments) at different cross-track angles. Any given mammal at depth near the trackline would be in the main beam for only one or two of the segments. Also, marine mammals that encounter the Kongsberg EM 122 are unlikely to be subjected to repeated pulses because of the narrow fore-aft width of the beam and will receive only limited amounts of pulse energy because of the short pulses.

Animals close to the vessel (where the beam is narrowest) are especially unlikely to be ensonified for more than one 2- to 15-ms pulse (or two pulses if in the overlap area). Similarly, Kremser et al. (2005) noted that the probability of a cetacean swimming through the area of exposure when an echosounder emits a pulse is small. The animal would have to pass the transducer at close range and be swimming at speeds similar to the vessel in order to receive the multiple pulses that might result in sufficient exposure to cause temporary threshold shift.

Navy sonars linked to avoidance reactions and stranding of cetaceans: (1) generally have longer pulse duration than the Kongsberg EM 122; and (2) are often directed close to horizontally versus more downward for the echosounder. The area of possible influence of the echosounder is much smaller—a narrow band below the source vessel. Also, the duration of exposure for a given marine mammal can be much longer for naval sonar. During the Observatory's operations, the individual pulses will be very short, and a given mammal would not receive many of the downward-directed pulses as the vessel passes by the animal. The following section outlines possible effects of an echosounder on marine mammals.

Masking—Marine mammal communications will not be masked appreciably by the echosounder's signals given the low duty cycle of the echosounder and the brief period when an individual mammal is likely to be within its beam. Furthermore, in the case of baleen whales, the echosounder's signals (12 kHz) do not overlap with the predominant frequencies in the calls, which would avoid any significant masking.

Behavioral Responses—Behavioral reactions of free-ranging marine mammals to sonars, echosounders, and other sound sources appear to vary by species and

circumstance. Observed reactions have included silencing and dispersal by sperm whales (Watkins et al., 1985), increased vocalizations and no dispersal by pilot whales (Globicephala melas) (Rendell and Gordon, 1999), and the previously-mentioned beachings by beaked whales. During exposure to a 21 to 25 kHz “whale-finding” sonar with a source level of 215 dB re: 1 μ Pa, gray whales reacted by orienting slightly away from the source and being deflected from their course by approximately 200 m (Frankel, 2005). When a 38-kHz echosounder and a 150-kHz acoustic Doppler current profiler were transmitting during studies in the eastern Tropical Pacific Ocean, baleen whales showed no significant responses, while spotted and spinner dolphins were detected slightly more often and beaked whales less often during visual surveys (Gerrodette and Pettis, 2005).

Captive bottlenose dolphins and a beluga whale exhibited changes in behavior when exposed to 1-s tonal signals at frequencies similar to those that will be emitted by the Observatory’s echosounder, and to shorter broadband pulsed signals. Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure (Schlundt et al., 2000; Finneran et al., 2002; Finneran and Schlundt, 2004). The relevance of those data to free-ranging odontocetes is uncertain, and in any case, the test sounds were quite different in duration as compared with those from an echosounder.

Hearing Impairment and Other Physical Effects—Given recent stranding events that have been associated with the operation of naval sonar, there is concern that mid-frequency sonar sounds can cause serious impacts to marine mammals (see above). However, the echosounder proposed for use by the Observatory is quite different than sonar used for navy operations. The echosounder’s pulse duration is very short relative

to the naval sonar. Also, at any given location, an individual marine mammal would be in the echosounder's beam for much less time given the generally downward orientation of the beam and its narrow fore-aft beamwidth; navy sonar often uses near-horizontally-directed sound. Those factors would all reduce the sound energy received from the echosounder relative to that from naval sonar.

Based upon the best available science, we believe that the brief exposure of marine mammals to one pulse, or small numbers of signals, from the echosounder is not likely to result in the harassment of marine mammals.

Sub-bottom Profiler

The Observatory will also operate a sub-bottom profiler from the source vessel during the proposed survey. The profiler's sounds are very short pulses, occurring for one to four ms once every second. Most of the energy in the sound pulses emitted by the profiler is at 3.5 kHz, and the beam is directed downward. The sub-bottom profiler on the Langseth has a maximum source level of 222 dB re: 1 μ Pa.

Kremser et al. (2005) noted that the probability of a cetacean swimming through the area of exposure when a bottom profiler emits a pulse is small—even for a profiler more powerful than that on the Langseth—if the animal was in the area, it would have to pass the transducer at close range and in order to be subjected to sound levels that could cause temporary threshold shift.

Masking—Marine mammal communications will not be masked appreciably by the profiler's signals given the directionality of the signal and the brief period when an individual mammal is likely to be within its beam. Furthermore, in the case of most baleen whales, the profiler's signals do not overlap with the predominant frequencies in

the calls, which would avoid significant masking.

Behavioral Responses—Marine mammal behavioral reactions to other pulsed sound sources are discussed above, and responses to the profiler are likely to be similar to those for other pulsed sources if received at the same levels. However, the pulsed signals from the profiler are considerably weaker than those from the echosounder. Therefore, behavioral responses are not expected unless marine mammals are very close to the source.

Hearing Impairment and Other Physical Effects—It is unlikely that the profiler produces pulse levels strong enough to cause hearing impairment or other physical injuries even in an animal that is (briefly) in a position near the source. The profiler operates simultaneously with other higher-power acoustic sources. Many marine mammals will move away in response to the approaching higher-power sources or the vessel itself before the mammals would be close enough for there to be any possibility of effects from the less intense sounds from the profiler. Based upon the best available science, we believe that the brief exposure of marine mammals to signals from the profiler is not likely to result in the harassment of marine mammals.

Potential Effects of Vessel Movement and Collisions

Vessel movement in the vicinity of marine mammals has the potential to result in either a behavioral response or a direct physical interaction. Both scenarios are discussed below this section.

Behavioral Responses to Vessel Movement

There are limited data concerning marine mammal behavioral responses to vessel traffic and vessel noise, and a lack of consensus among scientists with respect to what

these responses mean or whether they result in short-term or long-term adverse effects. In those cases where there is a busy shipping lane or where there is a large amount of vessel traffic, marine mammals may experience acoustic masking (Hildebrand, 2005) if they are present in the area (e.g., killer whales in Puget Sound; Foote et al., 2004; Holt et al., 2008). In cases where vessels actively approach marine mammals (e.g., whale watching or dolphin watching boats), scientists have documented that animals exhibit altered behavior such as increased swimming speed, erratic movement, and active avoidance behavior (Bursk, 1983; Acevedo, 1991; Baker and MacGibbon, 1991; Trites and Bain, 2000; Williams et al., 2002; Constantine et al., 2003), reduced blow interval (Ritcher et al., 2003), disruption of normal social behaviors (Lusseau, 2003; 2006), and the shift of behavioral activities which may increase energetic costs (Constantine et al., 2003; 2004)). A detailed review of marine mammal reactions to ships and boats is available in Richardson et al. (1995). For each of the marine mammal taxonomy groups, Richardson et al. (1995) provides the following assessment regarding reactions to vessel traffic:

Toothed whales: “In summary, toothed whales sometimes show no avoidance reaction to vessels, or even approach them. However, avoidance can occur, especially in response to vessels of types used to chase or hunt the animals. This may cause temporary displacement, but we know of no clear evidence that toothed whales have abandoned significant parts of their range because of vessel traffic.”

Baleen whales: “When baleen whales receive low-level sounds from distant or stationary vessels, the sounds often seem to be ignored. Some whales approach the sources of these sounds. When vessels approach whales slowly and non-aggressively,

whales often exhibit slow and inconspicuous avoidance maneuvers. In response to strong or rapidly changing vessel noise, baleen whales often interrupt their normal behavior and swim rapidly away. Avoidance is especially strong when a boat heads directly toward the whale.”

Behavioral responses to stimuli are complex and influenced to varying degrees by a number of factors, such as species, behavioral contexts, geographical regions, source characteristics (moving or stationary, speed, direction, etc.), prior experience of the animal and physical status of the animal. For example, studies have shown that beluga whales’ reactions varied when exposed to vessel noise and traffic. In some cases, naive beluga whales exhibited rapid swimming from ice-breaking vessels up to 80 km (49.7 mi) away, and showed changes in surfacing, breathing, diving, and group composition in the Canadian high Arctic where vessel traffic is rare (Finley *et al.*, 1990). In other cases, beluga whales were more tolerant of vessels, but responded differentially to certain vessels and operating characteristics by reducing their calling rates (especially older animals) in the St. Lawrence River where vessel traffic is common (Blane and Jaakson, 1994). In Bristol Bay, Alaska, beluga whales continued to feed when surrounded by fishing vessels and resisted dispersal even when purposefully harassed (Fish and Vania, 1971).

In reviewing more than 25 years of whale observation data, Watkins (1986) concluded that whale reactions to vessel traffic were “modified by their previous experience and current activity: habituation often occurred rapidly, attention to other stimuli or preoccupation with other activities sometimes overcame their interest or wariness of stimuli.” Watkins noticed that over the years of exposure to ships in the

Cape Cod area, minke whales changed from frequent positive interest (e.g., approaching vessels) to generally uninterested reactions; fin whales changed from mostly negative (e.g., avoidance) to uninterested reactions; right whales apparently continued the same variety of responses (negative, uninterested, and positive responses) with little change; and humpbacks dramatically changed from mixed responses that were often negative to reactions that were often strongly positive. Watkins (1986) summarized that “whales near shore, even in regions with low vessel traffic, generally have become less wary of boats and their noises, and they have appeared to be less easily disturbed than previously. In particular locations with intense shipping and repeated approaches by boats (such as the whale-watching areas of Stellwagen Bank), more and more whales had positive reactions to familiar vessels, and they also occasionally approached other boats and yachts in the same ways.”

Although the radiated sound from the Langseth will be audible to marine mammals over a large distance, it is unlikely that animals will respond behaviorally (in a manner that we would consider MMPA harassment) to low-level distant shipping noise as the animals in the area are likely to be habituated to such noises (Nowacek et al., 2004). In light of these facts, we do not expect the Langseth's movements to result in Level B harassment.

Vessel Strike

Ship strikes of cetaceans can cause major wounds, which may lead to the death of the animal. An animal at the surface could be struck directly by a vessel, a surfacing animal could hit the bottom of a vessel, or an animal just below the surface could be cut by a vessel's propeller. The severity of injuries typically depends on the size and speed of the

vessel (Knowlton and Kraus, 2001; Laist et al., 2001; Vanderlaan and Taggart, 2007).

The most vulnerable marine mammals are those that spend extended periods of time at the surface in order to restore oxygen levels within their tissues after deep dives (e.g., the sperm whale). In addition, some baleen whales, such as the North Atlantic right whale, seem generally unresponsive to vessel sound, making them more susceptible to vessel collisions (Nowacek et al., 2004). These species are primarily large, slow moving whales. Smaller marine mammals (e.g., bottlenose dolphin) move quickly through the water column and are often seen riding the bow wave of large ships. Marine mammal responses to vessels may include avoidance and changes in dive pattern (NRC, 2003).

An examination of all known ship strikes from all shipping sources (civilian and military) indicates vessel speed is a principal factor in whether a vessel strike results in death (Knowlton and Kraus, 2001; Laist et al., 2001; Jensen and Silber, 2003; Vanderlaan and Taggart, 2007). In assessing records in which vessel speed was known, Laist et al. (2001) found a direct relationship between the occurrence of a whale strike and the speed of the vessel involved in the collision. The authors concluded that most deaths occurred when a vessel was traveling in excess of 14.9 mph (24.1 km/hr; 13 kts).

The Observatory's proposed operation of one vessel for the proposed survey is relatively small in scale compared to the number of commercial ships transiting at higher speeds in the same areas on an annual basis. The probability of vessel and marine mammal interactions occurring during the proposed survey is unlikely due to the Langseth's slow operational speed, which is typically 4.6 kts (8.5 km/h; 5.3 mph). Outside of operations, the Langseth's cruising speed would be approximately 11.5 mph (18.5 km/h; 10 kts) which is generally below the speed at which studies have noted

reported increases of marine mammal injury or death (Laist et al., 2001).

As a final point, the Langseth has a number of other advantages for avoiding ship strikes as compared to most commercial merchant vessels, including the following: the Langseth's bridge offers good visibility to visually monitor for marine mammal presence; observers posted during operations scan the ocean for marine mammals and must report visual alerts of marine mammal presence to crew; and the observers receive extensive training that covers the fundamentals of visual observing for marine mammals and information about marine mammals and their identification at sea.

The potential effects to marine mammals described in this section of the document do not take into consideration the proposed monitoring and mitigation measures described later in this document (see the "Proposed Mitigation" and "Proposed Monitoring and Reporting" sections) which, as noted are designed to effect the least practicable adverse impact on affected marine mammal species and stocks.

Anticipated Effects on Marine Mammal Habitat

The proposed seismic survey is not anticipated to have any permanent impact on habitats used by the marine mammals in the proposed survey area, including the food sources they use (i.e., fish and invertebrates). Additionally, no physical damage to any habitat is anticipated as a result of conducting the proposed seismic survey. While it is anticipated that the specified activity may result in marine mammals avoiding certain areas due to temporary ensonification, this impact to habitat is temporary and reversible and was considered in further detail earlier in this document, as behavioral modification.

The main impact associated with the proposed activity will be temporarily elevated noise levels and the associated direct effects on marine mammals, previously discussed in

this notice. The next section discusses the potential impacts of anthropogenic sound sources on common marine mammal prey in the proposed survey area (i.e., fish and invertebrates).

Anticipated Effects on Fish

One reason for the adoption of airguns as the standard energy source for marine seismic surveys is that, unlike explosives, they have not been associated with large-scale fish kills. However, existing information on the impacts of seismic surveys on marine fish populations is limited (see Appendix D of the Foundation's Assessment). There are three types of potential effects of exposure to seismic surveys: (1) Pathological, (2) physiological, and (3) behavioral. Pathological effects involve lethal and temporary or permanent sub-lethal injury. Physiological effects involve temporary and permanent primary and secondary stress responses, such as changes in levels of enzymes and proteins. Behavioral effects refer to temporary and (if they occur) permanent changes in exhibited behavior (e.g., startle and avoidance behavior). The three categories are interrelated in complex ways. For example, it is possible that certain physiological and behavioral changes could potentially lead to an ultimate pathological effect on individuals (i.e., mortality).

The specific received sound levels at which permanent adverse effects to fish potentially could occur are little studied and largely unknown. Furthermore, the available information on the impacts of seismic surveys on marine fish is from studies of individuals or portions of a population; there have been no studies at the population scale. The studies of individual fish have often been on caged fish that were exposed to airgun pulses in situations not representative of an actual seismic survey. Thus, available

information provides limited insight on possible real-world effects at the ocean or population scale.

Hastings and Popper (2005), Popper (2009), and Popper and Hastings (2009a,b) provided recent critical reviews of the known effects of sound on fish. The following sections provide a general synopsis of the available information on the effects of exposure to seismic and other anthropogenic sound as relevant to fish. The information comprises results from scientific studies of varying degrees of rigor plus some anecdotal information. Some of the data sources may have serious shortcomings in methods, analysis, interpretation, and reproducibility that must be considered when interpreting their results (see Hastings and Popper, 2005). Potential adverse effects of the program's sound sources on marine fish are then noted.

Pathological Effects—The potential for pathological damage to hearing structures in fish depends on the energy level of the received sound and the physiology and hearing capability of the species in question (see Appendix D of the Foundation's Assessment). For a given sound to result in hearing loss, the sound must exceed, by some substantial amount, the hearing threshold of the fish for that sound (Popper, 2005). The consequences of temporary or permanent hearing loss in individual fish on a fish population are unknown; however, they likely depend on the number of individuals affected and whether critical behaviors involving sound (e.g., predator avoidance, prey capture, orientation and navigation, reproduction, etc.) are adversely affected.

Little is known about the mechanisms and characteristics of damage to fish that may be inflicted by exposure to seismic survey sounds. Few data have been presented in the peer-reviewed scientific literature. As far as we know, there are only two papers with

proper experimental methods, controls, and careful pathological investigation implicating sounds produced by actual seismic survey airguns in causing adverse anatomical effects. One such study indicated anatomical damage, and the second indicated temporary threshold shift in fish hearing. The anatomical case is McCauley *et al.* (2003), who found that exposure to airgun sound caused observable anatomical damage to the auditory maculae of pink snapper (*Pagrus auratus*). This damage in the ears had not been repaired in fish sacrificed and examined almost two months after exposure. On the other hand, Popper *et al.* (2005) documented only temporary threshold shift (as determined by auditory brainstem response) in two of three fish species from the Mackenzie River Delta. This study found that broad whitefish (*Coregonus nasus*) exposed to five airgun shots were not significantly different from those of controls. During both studies, the repetitive exposure to sound was greater than would have occurred during a typical seismic survey. However, the substantial low-frequency energy produced by the airguns (less than 400 Hz in the study by McCauley *et al.* (2003) and less than approximately 200 Hz in Popper *et al.* (2005)) likely did not propagate to the fish because the water in the study areas was very shallow (approximately 9 m in the former case and less than two m in the latter). Water depth sets a lower limit on the lowest sound frequency that will propagate (i.e., the cutoff frequency) at about one-quarter wavelength (Urick, 1983; Rogers and Cox, 1988).

Wardle *et al.* (2001) suggested that in water, acute injury and death of organisms exposed to seismic energy depends primarily on two features of the sound source: (1) The received peak pressure, and (2) the time required for the pressure to rise and decay. Generally, as received pressure increases, the period for the pressure to rise and decay

decreases, and the chance of acute pathological effects increases. According to Buchanan et al. (2004), for the types of seismic airguns and arrays involved with the proposed program, the pathological (mortality) zone for fish would be expected to be within a few meters of the seismic source. Numerous other studies provide examples of no fish mortality upon exposure to seismic sources (Falk and Lawrence, 1973; Holliday et al., 1987; La Bella et al., 1996; Santulli et al., 1999; McCauley et al., 2000a,b, 2003; Bjarti, 2002; Thomsen, 2002; Hassel et al., 2003; Popper et al., 2005; Boeger et al., 2006).

Some studies have reported, some equivocally, that mortality of fish, fish eggs, or larvae can occur close to seismic sources (Kostyuchenko, 1973; Dalen and Knutsen, 1986; Booman et al., 1996; Dalen et al., 1996). Some of the reports claimed seismic effects from treatments quite different from actual seismic survey sounds or even reasonable surrogates. However, Payne et al. (2009) reported no statistical differences in mortality/morbidity between control and exposed groups of capelin eggs or monkfish larvae. Saetre and Ona (1996) applied a worst-case scenario, mathematical model to investigate the effects of seismic energy on fish eggs and larvae. They concluded that mortality rates caused by exposure to seismic surveys are so low, as compared to natural mortality rates, that the impact of seismic surveying on recruitment to a fish stock must be regarded as insignificant.

Physiological Effects—Physiological effects refer to cellular and/or biochemical responses of fish to acoustic stress. Such stress potentially could affect fish populations by increasing mortality or reducing reproductive success. Primary and secondary stress responses of fish after exposure to seismic survey sound appear to be temporary in all studies done to date (Sverdrup et al., 1994; Santulli et al., 1999; McCauley et al.,

2000a,b). The periods necessary for the biochemical changes to return to normal are variable and depend on numerous aspects of the biology of the species and of the sound stimulus (see Appendix D of the Foundation's Assessment).

Behavioral Effects—Behavioral effects include changes in the distribution, migration, mating, and catchability of fish populations. Studies investigating the possible effects of sound (including seismic survey sound) on fish behavior have been conducted on both uncaged and caged individuals (e.g., Chapman and Hawkins, 1969; Pearson et al., 1992; Santulli et al., 1999; Wardle et al., 2001; Hassel et al., 2003). Typically, in these studies fish exhibited a sharp startle response at the onset of a sound followed by habituation and a return to normal behavior after the sound ceased.

In general, any adverse effects on fish behavior or fisheries attributable to seismic testing may depend on the species in question and the nature of the fishery (season, duration, fishing method). They may also depend on the age of the fish, its motivational state, its size, and numerous other factors that are difficult, if not impossible, to quantify at this point, given such limited data on effects of airguns on fish, particularly under realistic at-sea conditions.

Anticipated Effects on Fisheries

It is possible that the Langseth's streamer may become entangled with various types of fishing gear. The Observatory will employ avoidance tactics as necessary to prevent conflict. It is not expected that the Observatory's operations will have a significant impact on fisheries in the western Pacific Ocean. Nonetheless, the Observatory will minimize the potential to have a negative impact on the fisheries by avoiding areas where fishing is actively underway.

There is general concern about potential adverse effects of seismic operations on fisheries, namely a potential reduction in the catchability of fish involved in fisheries. Although reduced catch rates have been observed in some marine fisheries during seismic testing, in a number of cases the findings are confounded by other sources of disturbance (Dalen and Raknes, 1985; Dalen and Knutsen, 1986; Lokkeborg, 1991; Skalski et al., 1992; Engas et al., 1996). In other airgun experiments, there was no change in catch per unit effort of fish when airgun pulses were emitted, particularly in the immediate vicinity of the seismic survey (Pickett et al., 1994; La Bella et al., 1996). For some species, reductions in catch may have resulted from a change in behavior of the fish, (e.g., a change in vertical or horizontal distribution), as reported in Slotte et al. (2004).

Anticipated Effects on Invertebrates

The existing body of information on the impacts of seismic survey sound on marine invertebrates is very limited. However, there is some unpublished and very limited evidence of the potential for adverse effects on invertebrates, thereby justifying further discussion and analysis of this issue. The three types of potential effects of exposure to seismic surveys on marine invertebrates are pathological, physiological, and behavioral. Based on the physical structure of their sensory organs, marine invertebrates appear to be specialized to respond to particle displacement components of an impinging sound field and not to the pressure component (Popper et al., 2001; see also Appendix E of the Foundation's Assessment).

The only information available on the impacts of seismic surveys on marine invertebrates involves studies of individuals; there have been no studies at the population scale. Thus, available information provides limited insight on possible real-world effects

at the regional or ocean scale. The most important aspect of potential impacts concerns how exposure to seismic survey sound ultimately affects invertebrate populations and their viability, including availability to fisheries.

Literature reviews of the effects of seismic and other underwater sound on invertebrates were provided by Moriyasu et al. (2004) and Payne et al. (2008). The following sections provide a synopsis of available information on the effects of exposure to seismic survey sound on species of decapod crustaceans and cephalopods, the two taxonomic groups of invertebrates on which most such studies have been conducted. The available information is from studies with variable degrees of scientific soundness and from anecdotal information. A more detailed review of the literature on the effects of seismic survey sound on invertebrates is in Appendix E of the Foundation's Assessment.

Pathological Effects—In water, lethal and sub-lethal injury to organisms exposed to seismic survey sound appears to depend on at least two features of the sound source: (1) The received peak pressure; and (2) the time required for the pressure to rise and decay. Generally, as received pressure increases, the period for the pressure to rise and decay decreases, and the chance of acute pathological effects increases. For the type of airgun array planned for the proposed program, the pathological (mortality) zone for crustaceans and cephalopods is expected to be within a few meters of the seismic source, at most; however, very few specific data are available on levels of seismic signals that might damage these animals. This premise is based on the peak pressure and rise/decay time characteristics of seismic airgun arrays currently in use around the world.

Some studies have suggested that seismic survey sound has a limited pathological impact on early developmental stages of crustaceans (Pearson et al., 1994; Christian et

al., 2003; DFO, 2004). However, the impacts appear to be either temporary or insignificant compared to what occurs under natural conditions. Controlled field experiments on adult crustaceans (Christian et al., 2003, 2004; DFO, 2004) and adult cephalopods (McCauley et al., 2000a,b) exposed to seismic survey sound have not resulted in any significant pathological impacts on the animals. It has been suggested that exposure to commercial seismic survey activities has injured giant squid (Guerra et al., 2004), but the article provides little evidence to support this claim.

Andre et al. (2011) exposed four cephalopod species (Loligo vulgaris, Sepia officinalis, Octopus vulgaris, and Ilex coindetii) to two hours of continuous sound from 50 to 400 Hz at 157 ± 5 dB re: 1 μ Pa. They reported lesions to the sensory hair cells of the statocysts of the exposed animals that increased in severity with time, suggesting that cephalopods are particularly sensitive to low-frequency sound. The received sound pressure level was 157 ± 5 dB re: 1 μ Pa, with peak levels at 175 dB re 1 μ Pa. As in the McCauley et al. (2003) paper on sensory hair cell damage in pink snapper as a result of exposure to seismic sound, the cephalopods were subjected to higher sound levels than they would be under natural conditions, and they were unable to swim away from the sound source.

Physiological Effects—Physiological effects refer mainly to biochemical responses by marine invertebrates to acoustic stress. Such stress potentially could affect invertebrate populations by increasing mortality or reducing reproductive success. Primary and secondary stress responses (i.e., changes in haemolymph levels of enzymes, proteins, etc.) of crustaceans have been noted several days or months after exposure to seismic survey sounds (Payne et al., 2007). The periods necessary for these biochemical

changes to return to normal are variable and depend on numerous aspects of the biology of the species and of the sound stimulus.

Behavioral Effects—There is increasing interest in assessing the possible direct and indirect effects of seismic and other sounds on invertebrate behavior, particularly in relation to the consequences for fisheries. Changes in behavior could potentially affect such aspects as reproductive success, distribution, susceptibility to predation, and catchability by fisheries. Studies investigating the possible behavioral effects of exposure to seismic survey sound on crustaceans and cephalopods have been conducted on both uncaged and caged animals. In some cases, invertebrates exhibited startle responses (e.g., squid in McCauley *et al.*, 2000a,b). In other cases, no behavioral impacts were noted (e.g., crustaceans in Christian *et al.*, 2003, 2004; DFO, 2004). There have been anecdotal reports of reduced catch rates of shrimp shortly after exposure to seismic surveys; however, other studies have not observed any significant changes in shrimp catch rate (Andriguetto-Filho *et al.*, 2005). Similarly, Parry and Gason (2006) did not find any evidence that lobster catch rates were affected by seismic surveys. Any adverse effects on crustacean and cephalopod behavior or fisheries attributable to seismic survey sound depend on the species in question and the nature of the fishery (season, duration, fishing method).

Proposed Mitigation

In order to issue an incidental take authorization under section 101(a)(5)(D) of the Marine Mammal Protection Act, we must set forth the permissible methods of taking pursuant to such activity, and other means of effecting the least practicable adverse impact on such species or stock and its habitat, paying particular attention to rookeries,

mating grounds, and areas of similar significance, and the availability of such species or stock for taking for certain subsistence uses.

The Observatory has based the mitigation measures which they will implement during the proposed seismic survey, on the following:

- (1) Protocols used during previous seismic research cruises as approved by us;
- (2) Previous incidental harassment authorizations applications and authorizations that we have approved and authorized; and
- (3) Recommended best practices in Richardson et al. (1995), Pierson et al. (1998), and Weir and Dolman, (2007).

To reduce the potential for disturbance from acoustic stimuli associated with the activities, the Observatory and/or its designees would implement the following mitigation measures for marine mammals:

- (1) Proposed exclusion zones;
- (2) Power down procedures;
- (3) Shutdown procedures; and
- (4) Ramp-up procedures.

Proposed Exclusion Zones—The Observatory uses safety radii to designate exclusion zones and to estimate take for marine mammals. Table 2 (presented earlier in this document) shows the distances at which one would expect to receive three sound levels (160-, 180-, and 190-dB) from the 36-airgun array and a single airgun. The 180-dB and 190-dB level shutdown criteria are applicable to cetaceans and pinnipeds, respectively, as specified by us (2000). The Observatory used these levels to establish the exclusion zones.

If the protected species visual observer detects marine mammal(s) within or about to enter the appropriate exclusion zone, the Langseth crew will immediately power down the airgun array, or perform a shutdown if necessary (see Shut-down Procedures).

Power Down Procedures—A power down involves decreasing the number of airguns in use such that the radius of the 180-dB (or 190-dB) zone is smaller to the extent that marine mammals are no longer within or about to enter the exclusion zone. A power down of the airgun array can also occur when the vessel is moving from one seismic line to another. During a power down for mitigation, the Observatory will operate one airgun (40 in³). The continued operation of one airgun is intended to alert marine mammals to the presence of the seismic vessel in the area. In contrast, a shutdown occurs when the Langseth suspends all airgun activity.

If the observer detects a marine mammal outside the exclusion zone and the animal is likely to enter the zone, the crew will power down the airguns to reduce the size of the 180-dB exclusion zone before the animal enters that zone.

Likewise, if a mammal is already within the zone when first detected, the crew will power-down the airguns immediately. During a power down of the airgun array, the crew will operate a single 40-in³ airgun which has a smaller exclusion zone. If the observer detects a marine mammal within or near the smaller exclusion zone around the airgun (Table 2), the crew will shut down the single airgun (see next section).

Shutdown Procedures – The Langseth crew will shutdown the operating airgun(s) if a marine mammal is seen within or approaching the exclusion zone for the single airgun. The crew will implement a shutdown:

(1) If an animal enters the exclusion zone of the single airgun after the crew has initiated a power down; or

(2) If an animal is initially seen within the exclusion zone of the single airgun when more than one airgun (typically the full airgun array) is operating.

Considering the conservation status for north Pacific right whales, the Langseth crew will shutdown the airgun(s) immediately in the unlikely event that this species is observed, regardless of the distance from the vessel.

Resuming Airgun Operations After a Power Down

Following a power-down, the Langseth crew will not resume full airgun activity until the marine mammal has cleared the 180-dB exclusion zone (see Table 2). The observers will consider the animal to have cleared the exclusion zone if:

- The observer has visually observed the animal leave the exclusion zone, or
- An observer has not sighted the animal within the exclusion zone for 15 minutes for species with shorter dive durations (i.e., small odontocetes or pinnipeds), or 30 minutes for species with longer dive durations (i.e., mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales); or
- The vessel has transited outside the original 180-dB exclusion zone after an 8-minute wait period. This period is based on the 180-dB exclusion zone for the 36-airgun array (940 m) towed at a depth of 9 m (29.5 ft) in relation to the average speed of the Langseth while operating the airguns (8.5 km/h; 5.3 mph).

The Langseth crew will resume operating the airguns at full power after 15 minutes of sighting any species with short dive durations (i.e., small odontocetes or pinnipeds).

Likewise, the crew will resume airgun operations at full power after 30 minutes of

sighting any species with longer dive durations (i.e., mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales).

Because the vessel has transited 1.13 km (3,707 feet) away from the vicinity of the original sighting during the 8-minute period, implementing ramp-up procedures for the full array after an extended power down (i.e., transiting for an additional 35 minutes from the location of initial sighting) would not meaningfully increase the effectiveness of observing marine mammals approaching or entering the exclusion zone for the full source level and would not further minimize the potential for take. The Langseth's observers are continually monitoring the exclusion zone for the full source level while the mitigation airgun is firing. On average, observers can observe to the horizon (10 km; 6.2 mi) from the height of the Langseth's observation deck and should be able to say with a reasonable degree of confidence whether a marine mammal would be encountered within this distance before resuming airgun operations at full power.

Resuming Airgun Operations After a Shutdown

Following a shutdown, the Langseth crew will initiate a ramp-up with the smallest airgun in the array (40-in³). The crew will turn on additional airguns in a sequence such that the source level of the array will increase in steps not exceeding 6 dB per five-minute period over a total duration of approximately 30 minutes. During ramp-up, the observers will monitor the exclusion zone, and if he/she sights a marine mammal, the Langseth crew will implement a power down or shutdown as though the full airgun array were operational.

During periods of active seismic operations, there are occasions when the Langseth crew will need to temporarily shut down the airguns due to equipment failure or for

maintenance. In this case, if the airguns are inactive longer than eight minutes, the crew will follow ramp-up procedures for a shutdown described earlier and the observers will monitor the full exclusion zone and will implement a power down or shutdown if necessary.

If the full exclusion zone is not visible to the observer for at least 30 minutes prior to the start of operations in either daylight or nighttime, the Langseth crew will not commence ramp-up unless at least one airgun (40-in³ or similar) has been operating during the interruption of seismic survey operations. Given these provisions, it is likely that the vessel's crew will not ramp up the airgun array from a complete shutdown at night or in thick fog, because the outer part of the zone for that array will not be visible during those conditions.

If one airgun has operated during a power down period, ramp-up to full power will be permissible at night or in poor visibility, on the assumption that marine mammals will be alerted to the approaching seismic vessel by the sounds from the single airgun and could move away. The vessel's crew will not initiate a ramp-up of the airguns if a marine mammal is sighted within or near the applicable exclusion zones during the day or close to the vessel at night.

We have carefully evaluated the applicant's proposed mitigation measures and have considered a range of other measures in the context of ensuring that we have prescribed the means of effecting the least practicable adverse impact on the affected marine mammal species and stocks and their habitat. Our evaluation of potential measures included consideration of the following factors in relation to one another:

(1) The manner in which, and the degree to which, we expect that the successful implementation of the measure would minimize adverse impacts to marine mammals;

(2) The proven or likely efficacy of the specific measure to minimize adverse impacts as planned; and

(3) The practicability of the measure for applicant implementation.

Based on our evaluation of the Observatory's proposed measures, as well as other measures considered by us or recommended by the public, we have preliminarily determined that the mitigation measures provide the means of effecting the least practicable adverse impacts on marine mammals species or stocks and their habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance.

Proposed Monitoring and Reporting

In order to issue an incidental take authorization for an activity, section 101(a)(5)(D) of the Marine Mammal Protection Act states that we must set forth "requirements pertaining to the monitoring and reporting of such taking." The Act's implementing regulations at 50 CFR 216.104 (a)(13) indicate that requests for an authorization must include the suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species and our expectations of the level of taking or impacts on populations of marine mammals present in the action area.

Proposed Monitoring

The Observatory proposes to sponsor marine mammal monitoring during the present project, in order to implement the mitigation measures that require real-time monitoring, and to satisfy the monitoring requirements of the incidental harassment authorization.

We describe the Observatory's Monitoring Plan below this section. The Observatory

understands that this monitoring plan will be subject to review by us, and that we may require refinements to the plan. The Observatory has planned the monitoring work as a self-contained project independent of any other related monitoring projects that may occur in the same regions at the same time. Further, the Observatory would discuss coordination of its monitoring program with any other related work by other groups working in the same area, if practical.

Vessel-based Visual Monitoring

The Observatory will position observers aboard the seismic source vessel to watch for marine mammals near the vessel during daytime airgun operations and during any start-ups at night. Observers will also watch for marine mammals near the seismic vessel for at least 30 minutes prior to the start of airgun operations after an extended shutdown (i.e., greater than approximately eight minutes for this proposed cruise). When feasible, the observers will conduct observations during daytime periods when the seismic system is not operating for comparison of sighting rates and behavior with and without airgun operations and between acquisition periods. Based on the observations, the Langseth will power down or shutdown the airguns when marine mammals are observed within or about to enter a designated exclusion zone which is a region in which a possibility exists of adverse effects on animal hearing or other physical effects.

During seismic operations, at least four protected species observers will be aboard the Langseth. The Observatory will appoint the observers with our concurrence. They will conduct observations during ongoing daytime operations and nighttime ramp-ups of the airgun array. During the majority of seismic operations, two observers will be on duty from the observation tower to monitor marine mammals near the seismic vessel. Using

two observers will increase the effectiveness of detecting animals near the source vessel. However, during mealtimes and bathroom breaks, it is sometimes difficult to have two observers on effort, but at least one observer will be on watch during bathroom breaks and mealtimes. Observers will be on duty in shifts of no longer than four hours in duration.

Two observers will also be on visual watch during all nighttime ramp-ups of the seismic airguns. A third observer will monitor the passive acoustic monitoring equipment 24 hours a day to detect vocalizing marine mammals present in the action area. In summary, a typical daytime cruise would have scheduled two observers (visual) on duty from the observation tower, and a observer (acoustic) on the passive acoustic monitoring system. Before the start of the seismic survey, the Observatory will instruct the vessel's crew to assist in detecting marine mammals and implementing mitigation requirements.

The Langseth is a suitable platform for marine mammal observations. When stationed on the observation platform, the eye level will be approximately 21.5 m (70.5 ft) above sea level, and the observer will have a good view around the entire vessel. During daytime, the observers will scan the area around the vessel systematically with reticle binoculars (e.g., 7 x 50 Fujinon), Big-eye binoculars (25 x 150), and with the naked eye. During darkness, night vision devices will be available (ITT F500 Series Generation 3 binocular-image intensifier or equivalent), when required. Laser range-finding binoculars (Leica LRF 1200 laser rangefinder or equivalent) will be available to assist with distance estimation. Those are useful in training observers to estimate distances visually, but are generally not useful in measuring distances to animals directly; that is done primarily with the reticles in the binoculars.

When the observers see marine mammals within or about to enter the designated exclusion zone, the Langseth will immediately power down or shutdown the airguns if necessary. The observer(s) will continue to maintain watch to determine when the animal(s) are outside the exclusion zone by visual confirmation. Airgun operations will not resume until the observer has confirmed that the animal has left the zone, or if not observed after 15 minutes for species with shorter dive durations (small odontocetes and pinnipeds) or 30 minutes for species with longer dive durations (mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, killer, and beaked whales).

Passive Acoustic Monitoring

Passive acoustic monitoring will complement the visual monitoring program, when practicable. Visual monitoring typically is not effective during periods of poor visibility or at night, and even with good visibility, is unable to detect marine mammals when they are below the surface or beyond visual range. Acoustical monitoring can be used in conjunction with visual observations to improve detection, identification, and localization of cetaceans. The acoustic monitoring will serve to alert visual observers (if on duty) when vocalizing cetaceans are detected. It is only useful when marine mammals call, but it can be effective either by day or by night, and does not depend on good visibility. The acoustic observer will monitor the system in real time so that he/she can advise the visual observers if they acoustic detect cetaceans. When the acoustic observer determines the bearing (primary and mirror-image) to calling cetacean(s), he/she alert the visual observer to help him/her sight the calling animal(s).

The passive acoustic monitoring system consists of hardware (i.e., hydrophones) and software. The “wet end” of the system consists of a towed hydrophone array that is

connected to the vessel by a tow cable. The tow cable is 250 m (820.2 ft) long, and the hydrophones are fitted in the last 10 m (32.8 ft) of cable. A depth gauge is attached to the free end of the cable, and the cable is typically towed at depths less than 20 m (65.6 ft). The Langseth crew will deploy the array from a winch located on the back deck. A deck cable will connect the tow cable to the electronics unit in the main computer lab where the acoustic station, signal conditioning, and processing system will be located. The acoustic signals received by the hydrophones are amplified, digitized, and then processed by the Pamguard software. The system can detect marine mammal vocalizations at frequencies up to 250 kHz.

As described earlier, one acoustic observer, an expert bioacoustician with primary responsibility for the passive acoustic monitoring system will be aboard the Langseth in addition to the four visual observers. The acoustic observer will monitor the towed hydrophones 24 hours per day during airgun operations and during most periods when the Langseth is underway while the airguns are not operating. However, passive acoustic monitoring may not be possible if damage occurs to both the primary and back-up hydrophone arrays during operations. The primary passive acoustic monitoring streamer on the Langseth is a digital hydrophone streamer. Should the digital streamer fail, back-up systems should include an analog spare streamer and a hull-mounted hydrophone.

One acoustic observer will monitor the acoustic detection system by listening to the signals from two channels via headphones and/or speakers and watching the real-time spectrographic display for frequency ranges produced by cetaceans. The observer monitoring the acoustical data will be on shift for one to six hours at a time. The other

observers will rotate as an acoustic observer, although the expert acoustician will be on passive acoustic monitoring duty more frequently.

When the acoustic observer detects a vocalization while visual observations are in progress, the acoustic observer on duty will contact the visual observer immediately, to alert him/her to the presence of cetaceans (if they have not already been seen), so that the vessel's crew can initiate a power down or shutdown, if required. The observer will enter the information regarding the call into a database. Data entry will include an acoustic encounter identification number, whether it was linked with a visual sighting, date, time when first and last heard and whenever any additional information was recorded, position and water depth when first detected, bearing if determinable, species or species group (e.g., unidentified dolphin, sperm whale), types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information. The acoustic detection can also be recorded for further analysis.

Observer Data and Documentation

Observers will record data to estimate the numbers of marine mammals exposed to various received sound levels and to document apparent disturbance reactions or lack thereof. They will use the data to estimate numbers of animals potentially 'taken' by harassment (as defined in the MMPA). They will also provide information needed to order a power down or shut down of the airguns when a marine mammal is within or near the exclusion zone.

When an observer makes a sighting, they will record the following information:

1. Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from

seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g., none, avoidance, approach, paralleling, etc.), and behavioral pace.

2. Time, location, heading, speed, activity of the vessel, sea state, visibility, and sun glare.

The observer will record the data listed under (2) at the start and end of each observation watch, and during a watch whenever there is a change in one or more of the variables.

Observers will record all observations and power downs or shutdowns in a standardized format and will enter data into an electronic database. The observers will verify the accuracy of the data entry by computerized data validity checks as the data are entered and by subsequent manual checking of the database. These procedures will allow the preparation of initial summaries of data during and shortly after the field program, and will facilitate transfer of the data to statistical, graphical, and other programs for further processing and archiving.

Results from the vessel-based observations will provide:

1. The basis for real-time mitigation (airgun power down or shutdown).
2. Information needed to estimate the number of marine mammals potentially taken by harassment, which the Observatory must report to the Office of Protected Resources.
3. Data on the occurrence, distribution, and activities of marine mammals and turtles in the area where the Observatory will conduct the seismic study.
4. Information to compare the distance and distribution of marine mammals and turtles relative to the source vessel at times with and without seismic activity.

5. Data on the behavior and movement patterns of marine mammals detected during non-active and active seismic operations.

Proposed Reporting

The Observatory will submit a report to us and to the Foundation within 90 days after the end of the cruise. The report will describe the operations that were conducted and sightings of marine mammals and turtles near the operations. The report will provide full documentation of methods, results, and interpretation pertaining to all monitoring. The 90-day report will summarize the dates and locations of seismic operations, and all marine mammal sightings (dates, times, locations, activities, associated seismic survey activities). The report will also include estimates of the number and nature of exposures that could result in “takes” of marine mammals by harassment or in other ways.

In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by the authorization (if issued), such as an injury (Level A harassment), serious injury or mortality (e.g., ship-strike, gear interaction, and/or entanglement), the Observatory shall immediately cease the specified activities and immediately report the incident to the Incidental Take Program Supervisor, Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov and ITP.Cody@noaa.gov and to the Northwest Regional Stranding Coordinator at (206) 526-6550 (Brent.Norberg@noaa.gov). The report must include the following information:

- Time, date, and location (latitude/longitude) of the incident;
- Name and type of vessel involved;
- Vessel’s speed during and leading up to the incident;

- Description of the incident;
- Status of all sound source use in the 24 hours preceding the incident;
- Water depth;
- Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
- Description of all marine mammal observations in the 24 hours preceding the incident;
- Species identification or description of the animal(s) involved;
- Fate of the animal(s); and
- Photographs or video footage of the animal(s) (if equipment is available).

The Observatory shall not resume its activities until we are able to review the circumstances of the prohibited take. We shall work with the Observatory to determine what is necessary to minimize the likelihood of further prohibited take and ensure Marine Mammal Protection Act compliance. The Observatory may not resume their activities until notified by us via letter, email, or telephone.

In the event that the Observatory discovers an injured or dead marine mammal, and the lead visual observer determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as we describe in the next paragraph), the Observatory will immediately report the incident to the Incidental Take Program Supervisor, Permits and Conservation Division, Office of Protected Resources, at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov and ITP.Cody@noaa.gov and to the Northwest Regional Stranding Coordinator at (206) 526-6550 (Brent.Norberg@noaa.gov). The report must include the same information

identified in the paragraph above this section. Activities may continue while we review the circumstances of the incident. We will work with the Observatory to determine whether modifications in the activities are appropriate.

In the event that the Observatory discovers an injured or dead marine mammal, and the lead visual observer determines that the injury or death is not associated with or related to the authorized activities (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), the Observatory will report the incident to the Incidental Take Program Supervisor, Permits and Conservation Division, Office of Protected Resources, at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov and ITP.Cody@noaa.gov and the Northwest Regional Stranding Coordinator at (206) 526-6550 (Brent.Norberg@noaa.gov), within 24 hours of the discovery. The Observatory will provide photographs or video footage (if available) or other documentation of the stranded animal sighting to us.

Estimated Take by Incidental Harassment

Except with respect to certain activities not pertinent here, the Marine Mammal Protection Act defines "harassment" as: any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A harassment]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [Level B harassment].

We propose to authorize take by Level B harassment only for the proposed marine geophysical survey in the northwestern Pacific Ocean. Acoustic stimuli (i.e., increased

underwater sound) generated during the operation of the seismic airgun array may have the potential to cause marine mammals in the survey area to be exposed to sounds at or greater than 160 dB re: 1 μ Pa or cause temporary, short-term changes in behavior. There is no evidence that the Observatory's planned activities could result in injury, serious injury or mortality within the specified geographic area for the requested authorization. The required mitigation and monitoring measures will minimize any potential risk for injury, serious injury, or mortality.

The following sections describe the Observatory's methods to estimate take by incidental harassment and present their estimates of the numbers of marine mammals that could be affected during the proposed seismic program. The Observatory's estimates assume that marine mammals exposed to airgun sounds greater than or equal to 160 dB re: 1 μ Pa might change their behavior sufficiently for us to consider them as taken by harassment. They have based their estimates on the number of marine mammals that could be disturbed appreciably by operations with the 36-airgun array during approximately 4,991 km (3,101.2 mi) of transect lines in the northeastern Pacific Ocean.

We assume that during simultaneous operations of the airgun array and the other sources, any marine mammals close enough to be affected by the echosounder and sub-bottom profiler would already be affected by the airguns. However, whether or not the airguns are operating simultaneously with the other sources, we expect that the marine mammals would exhibit no more than short-term and inconsequential responses to the echosounder and profiler given their characteristics (e.g., narrow downward-directed beam) and other considerations described previously. Based on the best available information, we do not consider that these reactions constitute a "take" (NMFS, 2001).

Therefore, the Observatory did not provide any additional allowance for animals that could be affected by sound sources other than the airguns.

Ensonified Area Calculations—Because the Observatory assumes that the Langseth may need repeat some tracklines, accommodate the turning of the vessel, address equipment malfunctions, or conduct equipment testing to complete the survey; they have increased the proposed number of line-kilometers for the seismic operations by 25 percent (i.e., contingency lines).

The Observatory calculated the expected ensonified area by entering the planned survey lines (including the 25 percent contingency lines) into a Map-Info Geographic Information System (system). The Observatory used the system to draw a 160-dB radius (see Table 2) around the operating airgun array (i.e., the ensonified area) around each seismic line. This first calculation is the area excluding overlap.

Depending on the spacing of the transect lines within the ensonified area, the Observatory may also calculate areas of transit overlap. For example, if the ratio of transit overlap is 1.5 times the area excluding overlap, then the marine mammal that stayed within area during the entire survey could be exposed to acoustic stimuli approximately two times. However, it is unlikely that a particular animal would stay in the area during the entire survey. For the Juan de Fuca Survey, the transit lines are closely spaced together and the ratio of transect overlap is 1.7 greater than the area excluding overlapping transect lines. For the Cascadia Thrust Zone Survey the ratio is 2.8, and for the Cascadia Subduction Margin Survey the ratio is 2.0 times the area excluding overlap. Table 4 presents the area calculations for each survey. Refer to the authorization application and Assessment for additional information.

Table 4. Ensonified area calculations for three proposed seismic surveys in the northeast Pacific Ocean, during June-July, 2012.

Survey	Area Excluding Overlap (km²)	Area with Contingency Lines (km²)	Transect Line Spacing	Overlap Ratio (km²)
Juan de Fuca Plate	18,471	23,089	Closely spaced	1.7
Cascadia Thrust Zone	11,448	14,310	Closely spaced	2.8
Cascadia Subduction Margin	11,387	14,234	Closely spaced	2.0

Density Information— The Observatory calculated the density data for 26 species reported off the Oregon and Washington coasts in the northeastern Pacific Ocean using the following data sources:

- Pooled results of the 1991–2008 NMFS Southwest Fishery Science Center ship surveys as synthesized by Barlow and Forney (2007) and Barlow (2010) for all species except the gray whale and harbor porpoise.
- Abundance estimates for gray whales that remain between Oregon and B.C. in summer and the within area out to 43 km (26.7 mi) from shore in the U.S. Navy’s Keyport Range Complex Extension Environmental Impact Statement/Overseas Environmental Impact Statement (DoN, 2010); and
- The population estimate for the Northern Oregon/Washington Coast stock of harbor porpoises from the Pacific Marine Mammal Stock Assessments 2010 Report (Carretta *et al.*, 2010).

For the pooled results of the 1991–2008 NMFS Southwest Fishery Science Center ship surveys, the Observatory has corrected the densities for trackline detectability probability bias and availability bias. Trackline detectability probability bias is associated with diminishing sightability with increasing lateral distance from the track

line [$f(0)$]. Availability bias refers to the fact that there is less than a 100 percent probability of sighting an animal that is present along the survey track line, and it is measured by $g(0)$.

Exposure Calculations—The Observatory calculated the number of different individuals that could be exposed to airgun sounds with received levels greater than or equal to 160 dB re: 1 μ Pa by multiplying the expected density of the marine mammals by the ensonified area excluding areas of overlap. This area includes the 25 percent contingency lines.

Any marine mammal sightings within or near the designated exclusion zone will result in the shutdown of seismic operations as a mitigation measure. Thus, the following estimates of the numbers of marine mammals potentially exposed to 160 dB re: 1 μ Pa sounds are precautionary, and probably overestimate the actual numbers of marine mammals that might be involved. These estimates assume that there will be no weather, equipment, or mitigation delays, which is highly unlikely.

Because this approach does not allow for turnover in the mammal populations in the study area during the course of the survey, the actual number of individuals exposed could be underestimated. However, the approach assumes that no cetaceans will move away from or toward the trackline as the Langseth approaches in response to increasing sound levels prior to the time the levels reach 160 dB re: 1 μ Pa, which will result in overestimates for those species known to avoid seismic vessels.

Juan de Fuca Plate Survey Exposure Estimates

The total estimate of the number of individual cetaceans that could be exposed to seismic sounds with received levels greater than or equal to 160 dB re: 1 μ Pa during this

survey is 10,208 (see Table 5). The total includes 78 baleen whales, 56 of which are endangered: four blue whales (0.17 percent of the regional population), 30 fin whales (0.18 percent of the regional population), 19 humpback whales (0.09 percent of the regional population), and four sei whales (0.03 percent of the population). In addition, 24 sperm whales (0.10 percent of the regional population) and 303 Steller sea lions (0.46 percent of the population) (both listed as endangered under the Endangered Species Act) could be exposed during the survey.

Of the cetaceans potentially exposed, 57 percent are delphinids and 42 percent are pinnipeds. The most common species in the area potentially exposed to sound levels greater than or equal to 160 dB re: 1 μ Pa during the proposed survey would be harbor porpoises (2,153 or 4.12 percent), Dall's porpoises (1,935 or 4.61 percent), northern fur seals (1,931 or 0.30 percent), and northern elephant seals (1,058 or 0.85 percent).

Table 5. Estimates of the possible numbers of marine mammals exposed to sound levels greater than or equal to 160 dB re: 1 μ Pa during the proposed Juan de Fuca Plate Seismic Survey in the northeast Pacific Ocean, June-July, 2012.

Species	Estimated Number of Individuals Exposed to Sound Levels ≥ 160 dB re: 1 μPa¹	Requested or Adjusted Take Authorization	Approximate Percent of Regional Population²
Gray whale	10	10	0
Humpback whale	19	19	0.09
Minke whale	11	11	0.12
Sei whale	4	4	0.03
Fin whale	30	30	0.18
Blue whale	4	4	0.17
Odontocetes			
Sperm whale	24	24	0.10
Pygmy/Dwarf sperm whale	16	16	N/A
Cuvier's beaked whale	10	10	0.46
Baird's beaked whale	27	27	3.0
Mesoplodon spp. ³	40	40	3.95
Striped dolphin	1	2 ⁴	0.01
Short-beaked common dolphin	237	238 ⁴	0.06
Pacific white-sided dolphin	806	806	299
Northern right whale dolphin	297	297	3.57
Risso's dolphin	258	258	4.12
Killer whale	38	38	1.55
Harbor porpoise ⁵	2,153	2,153	4.12
Dall's porpoise	1,935	1,935	4.61
Pinnipeds			
Northern fur seal	1,931	1,931	0.30
Steller sea lion	303	303	0.46
Harbor seal ⁵	995	995	4.02
Northern elephant seal	1,058	1,058	0.85

N/A = Not Available

¹ Estimates are based on densities in Table 3 and an ensounded area (including 25% contingency of 23,089 km²).

² Regional population size estimates are from Table 3 (page 48 in Application #1).

³ Includes Blainville's, Stejneger's, and Hubb's beaked whales.

⁴ Requested take authorization increased to mean group size (see Application #1).

⁵ Estimates based on densities from Table 3 (page 48 in Application #1) and an ensounded area in water depths less than 100 m (328 ft) (including 25 percent contingency) of 3,404 km².

Cascadia Thrust Zone Survey Exposure Estimates

The total estimate of the number of individual cetaceans that could be exposed to seismic sounds with received levels greater than or equal to 160 dB re: 1 μ Pa during this survey is 15,100 (see Table 6). The total includes 79 baleen whales, 35 of which are endangered: three blue whales (0.10 percent of the regional population), 18 fin whales (0.11 percent of the regional population), 12 humpback whales (0.06 percent of the regional population), and two sei whales (0.02 percent of the population). In addition, 15 sperm whales (0.06 percent of the regional population) and 188 Steller sea lions (0.29 percent of the population) (both listed as endangered under the Endangered Species Act) could be exposed during the survey.

Of the cetaceans potentially exposed, 63 percent are delphinids and 36 percent are pinnipeds. The most common species in the area potentially exposed to sound levels greater than or equal to 160 dB re: 1 μ Pa during the proposed survey would be, Dall's porpoises (1,199 or 2.86 percent), harbor porpoises (7,314 or 14 percent of the regional population or 9.2 percent of the overall population), and harbor seals (3,380 or 13.67 percent of the regional population or 4.6% of the overall population) and northern fur seals (1,197 or 0.18 percent) (Allen and Angliss, 2011). The percentages for harbor porpoises and harbor seals are the upper boundaries of the regional populations that could be affected by the proposed survey. However, these take estimates are small relative to the overall population sizes for each species in the northeast Pacific. Thus, these take estimates are likely an overestimate of the actual number of animals that may be taken by Level B harassment and we expect that the actual number of individual animals that may be taken by Level B harassment to be less than the request.

Table 6. Estimates of the possible numbers of marine mammals exposed to sound levels greater than or equal to 160 dB re: 1 μ Pa during the proposed Cascadia Thrust Zone Seismic Survey in the northeast Pacific Ocean, July, 2012.

Species	Estimated Number of Individuals Exposed to Sound Levels ≥ 160 dB re: 1 μPa¹	Requested or Adjusted Take Authorization	Approximate Percent of Regional Population²
Gray whale	35	35	0.18
Humpback whale	12	12	0.06
Minke whale	7	7	0.07
Sei whale	2	2	0.02
Fin whale	18	18	0.11
Blue whale	3	3	0.10
Odontocetes			
Sperm whale	15	15	0.06
Pygmy/Dwarf sperm whale	10	10	NA
Cuvier's beaked whale	6	6	0.28
Baird's beaked whale	17	17	1.86
Mesoplodon spp. ³	25	25	2.45
Striped dolphin	1	2 ⁴	< 0.01
Short-beaked common dolphin	147	238 ⁴	0.04
Pacific white-sided dolphin	500	500	1.86
Northern right whale dolphin	184	184	2.21
Risso's dolphin	160	160	2.55
Killer whale	24	24	0.96
Harbor porpoise ⁵	7,314	7,314	14.00
Dall's porpoise	1,199	1,199	2.86
Pinnipeds			
Northern fur seal	1,197	1,197	0.18
Steller sea lion	188	188	0.29
Harbor seal ⁵	3,380	3,380	13.67
Northern elephant seal	656	656	0.53

N/A = Not Available

¹ Estimates are based on densities in Table 3 and an ensounded area (including 25% contingency of 14,310 km²).

² Regional population size estimates are from Table 3 (page 47 in Application #2).

³ Includes Blainville's, Stejneger's, and Hubb's beaked whales.

⁴ Requested take authorization increased to mean group size (see Application #2).

⁵ Estimates based on densities from Table 3 (page 47 in Application #2) and an ensounded area in water depths less than 100 m (328 ft) (including 25 percent contingency) of 11.565 km².

Cascadia Subduction Margin Survey Exposure Estimates

The total estimate of the number of individual cetaceans that could be exposed to seismic sounds with received levels greater than or equal to 160 dB re: 1 μ Pa during this survey is 8,132 (see Table 7). The total includes 54 baleen whales, 35 of which are endangered: three blue whales (0.10 percent of the regional population), 18 fin whales (0.11 percent of the regional population), 11 humpback whales (0.06 percent of the regional population), and two sei whales (0.02 percent of the population). In addition, 15 sperm whales (0.06 percent of the regional population) and 187 Steller sea lions (0.29 percent of the population) (both listed as endangered under the Endangered Species Act) could be exposed during the survey.

Of the cetaceans potentially exposed, 59 percent are delphinids and 40 percent are pinnipeds. The most common species in the area potentially exposed to sound levels greater than or equal to 160 dB re: 1 μ Pa during the proposed survey would be harbor porpoises (2,580 or 4.94 percent), Dall's porpoises (1,193 or 2.84 percent), northern fur seals (1,190 or 0.18 percent), and harbor seals (1,192 or 4.82 percent).

Table 7. Estimates of the possible numbers of marine mammals exposed to sound levels greater than or equal to 160 dB re: 1 μ Pa during the proposed Cascadia Subduction Margin Seismic Survey in the northeast Pacific Ocean, July, 2012.

Species	Estimated Number of Individuals Exposed to Sound Levels ≥ 160 dB re: 1 μPa¹	Requested or Adjusted Take Authorization	Approximate Percent of Regional Population²
Gray whale	12	12	0.06
Humpback whale	11	11	0.06
Minke whale	6	6	0.07
Sei whale	2	2	0.02
Fin whale	18	18	0.11
Blue whale	3	3	0.10
Odontocetes			
Sperm whale	15	15	0.06
Pygmy/Dwarf sperm whale	10	10	NA
Cuvier's beaked whale	6	6	0.28
Baird's beaked whale	17	17	1.85
Mesoplodon spp. ³	25	25	2.44
Striped dolphin	1	2 ⁴	< 0.01
Short-beaked common dolphin	146	238 ⁴	0.04
Pacific white-sided dolphin	497	497	1.85
Northern right whale dolphin	183	183	2.20
Risso's dolphin	159	159	2.54
Killer whale	24	24	0.96
Harbor porpoise ⁵	2,580	2,580	4.94
Dall's porpoise	1,193	1,193	2.84
Pinnipeds			
Northern fur seal	1,190	1,190	0.18
Steller sea lion	187	187	0.29
Harbor seal ⁵	1,192	1,192	4.82
Northern elephant seal	652	652	0.53

N/A = Not Available

¹ Estimates are based on densities in Table 3 and an ensounded area (including 25% contingency of 14,234 km²).

² Regional population size estimates are from Table 3 (page 47 in Application #3).

³ Includes Blainville's, Stejneger's, and Hubb's beaked whales.

⁴ Requested take authorization increased to mean group size (see Application #3).

⁵ Estimates based on densities from Table 3 (page 47 in Application #3) and an ensounded area in water depths less than 100 m (328 ft) (including 25 percent contingency) of 4,080 km².

Encouraging and Coordinating Research

The Observatory and the Foundation will coordinate the planned marine mammal monitoring program associated with each seismic survey in the northwestern Pacific Ocean with other parties that may have interest in the area and/or may be conducting marine mammal studies in the same region during the seismic surveys.

Negligible Impact and Small Numbers Analysis and Determination

We have defined “negligible impact” in 50 CFR 216.103 as “...an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival.” In making a negligible impact determination, we consider:

- (1) The number of anticipated injuries, serious injuries, or mortalities;
- (2) The number, nature, and intensity, and duration of Level B harassment (all relatively limited); and
- (3) The context in which the takes occur (i.e., impacts to areas of significance, impacts to local populations, and cumulative impacts when taking into account successive/contemporaneous actions when added to baseline data);
- (4) The status of stock or species of marine mammals (i.e., depleted, not depleted, decreasing, increasing, stable, impact relative to the size of the population);
- (5) Impacts on habitat affecting rates of recruitment/survival; and
- (6) The effectiveness of monitoring and mitigation measures.

For reasons stated previously in this document, the specified activities associated with the marine seismic surveys are not likely to cause permanent threshold shift, or other

non-auditory injury, serious injury, or death because:

(1) The likelihood that, given sufficient notice through relatively slow ship speed, we expect marine mammals to move away from a noise source that is annoying prior to its becoming potentially injurious;

(2) The potential for temporary or permanent hearing impairment is relatively low and that we would likely avoid this impact through the incorporation of the required monitoring and mitigation measures (described previously in this document);

(3) The fact that cetaceans would have to be closer than 940 m (3,084 ft) in deep water, 1,540 m (5,052 ft) in intermediate depths, and 2,140 m (7,020 ft) in shallow depths, when the 36-airgun array is in use at 9 m (29.5 ft) tow depth from the vessel to be exposed to levels of sound believed to have a minimal chance of causing permanent threshold shift;

(4) The fact that cetaceans would have to be closer than 1,100 m (3,609 ft) in deep water, 1,810 m (5,938 ft) in intermediate depths, and 2,520 m (8,268 ft) in shallow depths, when the 36-airgun array is in use at 12 m (39.4 ft) tow depth from the vessel to be exposed to levels of sound believed to have a minimal chance of causing permanent threshold shift;

(5) The fact that cetaceans would have to be closer than 1,200 m (3,937 ft) in deep water, 1,975 m (6,480 ft) in intermediate depths, and 2,750 m (9,022 ft) in shallow depths, when the 36-airgun array is in use at 15 m (49.2 ft) tow depth from the vessel to be exposed to levels of sound believed to have a minimal chance of causing permanent threshold shift;

(6) The fact that cetaceans would have to be closer than 40 m (131 ft) in deep water,

60 m (197 ft) in intermediate depths, and 296 m (971 ft) in shallow depths, when the single airgun is in use at six to 15 m (20 to 49.2 ft) tow depth from the vessel to be exposed to levels of sound believed to have a minimal chance of causing permanent threshold shift;

(7) The fact that pinnipeds would have to be closer than 400 m (1,312 ft) in deep water, 550 m (1,804 ft) in intermediate depths, and 680 m (2,231 ft) in shallow depths, when the 36-airgun array is in use at 9 m (29.5 ft) tow depth from the vessel to be exposed to levels of sound believed to have a minimal chance of causing permanent threshold shift;

(8) The fact that pinnipeds would have to be closer than 460 m (1,509 ft) in deep water, 615 m (2,018 ft) in intermediate depths, and 770 m (2,526 ft) in shallow depths, when the single airgun is in use at 12 m (39.4 ft) tow depth from the vessel to be exposed to levels of sound believed to have a minimal chance of causing permanent threshold shift;

(9) The fact that pinnipeds would have to be closer than 520 m (1,706 ft) in deep water, 690 m (2,264 ft) in intermediate depths, and 865 m (2,838 ft) in shallow depths, when the single airgun is in use at 15 m (49.2 ft) tow depth from the vessel to be exposed to levels of sound believed to have a minimal chance of causing permanent threshold shift;

(10) The fact that pinnipeds would have to be closer than 12 m (39.4 ft) in deep water, 18 m (59 ft) in intermediate depths, and 150 m (492 ft) in shallow depths, when the single airgun is in use at six to 15 m (20 to 49.2 ft) tow depth from the vessel to be exposed to levels of sound believed to have a minimal chance of causing permanent

threshold shift; and

(11) The likelihood that marine mammal detection ability by trained visual observers is high at close proximity to the vessel.

We do not anticipate that any injuries, serious injuries, or mortalities would occur as a result of the Observatory's planned marine seismic surveys, and we do not propose to authorize injury, serious injury or mortality for this survey. We anticipate only short-term behavioral disturbance to occur during the conduct of the survey activities. Tables 5, 6, and 7 of this document outline the number of requested Level B harassment takes that we anticipate as a result of these activities. Due to the nature, degree, and context of Level B (behavioral) harassment anticipated and described (see "Potential Effects on Marine Mammals" section in this notice), we do not expect the activity to impact rates of recruitment or survival for any affected species or stock. Further, the seismic surveys would not take place in areas of significance for marine mammal feeding, resting, breeding, or calving and would not adversely impact marine mammal habitat.

Many animals perform vital functions, such as feeding, resting, traveling, and socializing, on a diel cycle (i.e., 24 hour cycle). Behavioral reactions to noise exposure (such as disruption of critical life functions, displacement, or avoidance of important habitat) are more likely to be significant if they last more than one diel cycle or recur on subsequent days (Southall et al., 2007). While we anticipate that the seismic operations would occur on consecutive days, the estimated duration of the Juan de Fuca Plate survey would last no more than 17 days, the Cascadia Thrust Zone survey would last approximately three days, and the Cascadia Subduction Margin survey would occur over 10 days.

Because the Langseth will move continuously along planned tracklines, each seismic surveys would increase sound levels in the marine environment surrounding the vessel for 21 days during the first and second study and for 10 days during the last study. There will be an estimated 4-day period of non-seismic activity between the second and third survey.

Of the 31 marine mammal species under our jurisdiction that are known to occur or likely to occur in the study area, six of these species and two stocks are listed as endangered under the Endangered Species Act: the blue, fin, humpback, north Pacific right, sei, and sperm whales; the southern resident stock of killer whales; and the eastern U.S. stock of the Steller sea lion. These species are also categorized as depleted under the Marine Mammal Protection Act. With the exception of North Pacific right whales, the Observatory has requested authorized take for these listed species. To protect these animals (and other marine mammals in the study area), the Observatory must cease or reduce airgun operations if animals enter designated zones.

Based on available data, we do not expect the Observatory to encounter five of the 31 species under our jurisdiction in the proposed survey areas. They include the following: the north Pacific right, false killer, and short-finned pilot whales; the California sea lion; and the bottlenose dolphin because of the species' rare and/or extralimital occurrence in the survey areas. As mentioned previously, we estimate that 26 species of marine mammals under our jurisdiction could be potentially affected by Level B harassment over the course of the proposed authorization. For each species, these numbers are small, relative to the regional or overall population size and we have provided the regional population estimates for the marine mammal species that may be taken by Level B

harassment in Tables 5, 6, and 7 in this document. Our practice has been to apply the 160 dB re: 1 μ Pa received level threshold for underwater impulse sound levels to determine whether take by Level B harassment occurs. Southall et al. (2007) provides a severity scale for ranking observed behavioral responses of both free-ranging marine mammals and laboratory subjects to various types of anthropogenic sound (see Table 4 in Southall et al. [2007]).

We have preliminarily determined, provided that the aforementioned mitigation and monitoring measures are implemented, that the impact of conducting three marine seismic surveys off Oregon and Washington in the northwestern Pacific Ocean, June through July, 2012, may result, at worst, in a temporary modification in behavior and/or low-level physiological effects (Level B harassment) of small numbers of certain species of marine mammals. See Tables 5, 6, and 7 for the requested authorized take numbers of cetaceans.

While these species may make behavioral modifications, including temporarily vacating the area during the operation of the airgun(s) to avoid the resultant acoustic disturbance, the availability of alternate areas within these areas and the short duration of the research activities, have led us to preliminarily determine that this action will have a negligible impact on the species in the specified geographic region.

Based on the analysis contained herein of the likely effects of the specified activity on marine mammals and their habitat, and taking into consideration the implementation of the mitigation and monitoring measures, we preliminarily find that the Observatory's planned research activities will result in the incidental take of small numbers of marine mammals, by Level B harassment only, and that the required measures mitigate impacts

to affected species or stocks of marine mammals to the lowest level practicable.

Impact on Availability of Affected Species or Stock for Taking for Subsistence Uses

Section 101(a)(5)(D) of the Marine Mammal Protection Act also requires us to determine that the authorization will not have an unmitigable adverse effect on the availability of marine mammal species or stocks for subsistence use. There are no relevant subsistence uses of marine mammals in the study area (northeastern Pacific Ocean) that implicate section 101(a)(5)(D) of the Marine Mammal Protection Act.

Endangered Species Act

Of the species of marine mammals that may occur in the proposed survey area, several are listed as endangered under the Endangered Species Act, including the blue, fin, humpback, north Pacific right, sei, and sperm whales. The Observatory did not request take of endangered north Pacific right whales because of the low likelihood of encountering these species during the cruise.

Under section 7 of the Act, the Foundation has initiated formal consultation with the Service's, Office of Protected Resources, Endangered Species Act Interagency Cooperation Division, on this proposed seismic survey. We (i.e., National Marine Fisheries Service, Office of Protected Resources, Permits and Conservation Division), have also initiated formal consultation under section 7 of the Act with the Endangered Species Act Interagency Cooperation Division to obtain a Biological Opinion (Opinion) evaluating the effects of issuing an incidental harassment authorization for threatened and endangered marine mammals and, if appropriate, authorizing incidental take. We will conclude the formal section 7 consultation prior to making a determination on whether or not to issue the authorization. If we issue the take authorization, the Foundation and the

Observatory must comply with the Terms and Conditions of the Opinion's Incidental Take Statement in addition to the mitigation and monitoring requirements included in the issued take authorization.

National Environmental Policy Act (NEPA)

With its complete application, the Foundation and the Observatory provided an "Environmental Assessment and Finding of No Significant Impact Determination Pursuant to the National Environmental Policy Act, (NEPA: 42 U.S.C. 4321 et seq.) and Executive Order 12114 for a "Marine Seismic Survey in the northeastern Pacific Ocean, 2012," which incorporates an "Environmental Assessment of a Marine Geophysical Survey by the R/V Marcus G. Langseth in the northeastern Pacific Ocean, June - July 2012," prepared by LGL Limited environmental research associates.

The Assessment analyzes the direct, indirect, and cumulative environmental impacts of the specified activities on marine mammals including those listed as threatened or endangered under the Endangered Species Act. We have conducted an independent review and evaluation of the document for sufficiency and compliance with the Council of Environmental Quality and NOAA Administrative Order 216-6 § 5.09(d), Environmental Review Procedures for Implementing the National Environmental Policy Act, and have preliminarily determined that issuance of the incidental harassment authorization is not likely to result in significant impacts on the human environment. Consequently, we plan to adopt the Foundation's Assessment and intend to prepare a Finding of No Significant Impact for the issuance of the authorization.

Proposed Authorization

As a result of these preliminary determinations, we propose to authorize the take of marine mammals incidental to the Observatory's proposed marine seismic surveys in the northeast Pacific Ocean, provided the previously mentioned mitigation, monitoring, and reporting requirements are incorporated. The duration of the incidental harassment authorization would not exceed one year from the date of its issuance.

Information Solicited

We request interested persons to submit comments and information concerning this proposed project and our preliminary determination of issuing a take authorization (see ADDRESSES). Concurrent with the publication of this notice in the Federal Register, we will forward copies of this application to the Marine Mammal Commission and its Committee of Scientific Advisors.

Dated: April 27, 2012

Helen M. Golde,
Acting Director, Office of Protected Resources,
National Marine Fisheries Service.

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